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THE TREATMENT OF RAYNAUD'S DISEASE BY RESECTION OF THE UPPER THORACIC AND LUMBAR SYMPATHETIC GANGLIA AND TRUNKS[1]

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THE physiologic results obtained by the various operative procedures on the sympathetic nervous system have stimulated various physicians and surgeons to seek clinical application of the phenomena. Consequently, medical literature at present is filled with varying reports. This state of affairs will continue until knowledge of the anatomy and the physiology of the sympathetic nervous system has become established. While some of the data is contradictory and opinions differ, there will gradually crystallize general conceptions which will direct the clinical application of the various operative procedures. The present discussion will be devoted to general considerations and therapeutic effects obtained following resection of ganglia in the treatment of Raynaud's disease.

HISTORICAL DATA

The historical development of our knowledge of the diseases affecting the peripheral arteries is marked by four outstanding achievements. The first definite reference to the relationship of gangrene to disease of the arteries, to our knowledge, was that of Quesnay in 1739, but the idea of an obstacle to the course of the blood was clearly stated by Hébréard in 1817. The exact nature of this process, however, was made clear in the work on embolism and thrombosis done by Virchow, who called attention to the fact that the degeneration *per se* of the arterial wall was not sufficient to cause gangrene. His work clearly defined the mechanism for the genesis of gangrene due to embolism and thrombosis and gave a new direction to research. The second contribution was that of Raynaud in his thesis, in 1862, and in his "New Researches," in 1874. His studies brought out conclusively that there is a form of gangrene without demonstrable organic disease or occlusion of the arteries. Probably the first known case of this type of vascular disease was observed in 1629 and was described by Bernard Schroeder, a symmetric, recurring form of gangrene of the extremities in a young girl. Following the studies of Raynaud, advances in our clinical knowledge of the disease have been few. Hutchinson, in 1871, noted the association of paroxysmal hæmoglobinuria in some cases of local asphyxia. Since that time, many cases of this type have been reported by various workers. The translation of Raynaud's contributions into English by Barlow in 1888, and Monro's monograph in 1899, while not adding

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much new to the knowledge of the disease, served to draw the attention of English speaking physicians to this interesting condition. The description by Weir Mitchell in 1878 of another form of vasomotor neurosis which affects the extremities and is of the intermittent, dilating type which he termed erythromelalgia, constitutes the third important contribution.

The fourth mile post was marked by the contributions of von Winiwarter and later by those of Buerger, who separated from the group of arterial disease of an occlusive nature a clinical entity occurring almost exclusively in the male sex, termed by Buerger, thromboangiitis obliterans (10). Knowledge of this disease clarifies many of the doubtful cases which subsequently had erroneously been diagnosed as Raynaud's disease in the male sex.

CLINICAL FEATURES OF RAYNAUD'S DISEASE

A wide experience with various forms of vascular disease of the extremities allows a separation of the cases presenting vasomotor disturbances of the spastic type into four groups. First, there is a fairly large group of so-called normal persons, predominantly females, who have cold hands and feet, frequently have disturbances such as mild degrees of pallor in symmetric single digits, the so-called dead finger or mild cyanosis, usually associated with moist, clammy, cold extremities. These persons are frequently of the asthenic type, and suffer easily from cold. The surface temperature of the extremities is subject to wide fluctuations, depending on variations in the environmental temperature. This condition does not constitute a disease, as symptoms are usually absent and the physician is rarely consulted unless the changes in color are striking. These subjects are classified by Mueller (30) as having a "vasomotor constitution." We have designated them as suffering from subnormal vasomotor states. Second, there are gradations from these so-called normal persons to those in whom the disturbances in color in the extremities are more profound, frequently paroxysmal in nature, occurring with lesser degrees of lowered temperature. Attacks of pallor may alternate with or be followed in a period of months by more or less chronic states of cyanosis. The signs and symptoms are of sufficient intensity for the patient to seek advice from the physician. The symptoms usually consist of numbness, occasionally partial anæsthesia during the period of local asphyxia, extreme coldness during the stage of syncope, and dull aching distress during the periods of syncope and cyanosis. With high environmental temperature, the hands become excessively warm and red, accompanied by sensations of burning. Third, is another group of persons who have a further aggravation of the disturbance. The attacks of pallor become more intense, more painful, or a condition of chronic cyanosis or asphyxia supervenes; temporary recovery is much more difficult. The changes in color are induced by the least change in temperature. The hands and feet frequently become swollen and puffy; trophic disturbances then appear, consisting of minute areas of gangrene in the tips of the digits, with symmetric distribution. The fourth group consists of the more severe but much rarer type of case in which gangrene may develop in the entire end of symmetric digits without prolonged antecedent history of vasomotor disturbance. Pain may be a marked feature.

All of these groups fulfill the criteria laid down by Raynaud; namely, symmetry of the disturbances, intermittency or paroxysmal nature of the disturbance in accordance with its functional basis, and the existence of pulsations in the arteries of the affected part. We are of the opinion that the foregoing groups represent different degrees of the same underlying fault of the vasomotor mechanism, justifying the nomenclature of "vasomotor neurosis of the spastic type" and that the term Raynaud's disease should be reserved for the type of case included in the second, third, and fourth groups. The cases in the first two groups probably represent an exaggeration of the vasomotor changes which occur in the normal subject on exposure to cold. There is in the peripheral areas a transitory phase of pallor or cyanosis; with exposure to increased local or environmental temperature,

redness and increased surface temperature results.

ETIOLOGY

The etiology is unknown in the idiopathic or primary types of Raynaud's disease. The influence of heredity has not been striking; in the cases reviewed in the literature by Monro it approximates 8 per cent. While this is in line with our impression relative to the well marked cases of Raynaud's disease, the subnormal vasomotor types seem definitely of a constitutional nature, and many members of the same family exhibit this tendency.

The contributing factors are perhaps of more importance. The incidence of sex, we believe, is of great importance. In Raynaud's group of 25 cases, 80 per cent were females. If the cases of doubtful diagnosis in his group are eliminated, this percentage increases to 88. In the cases reviewed by Monro, 62.6 per cent were females and 37.4 per cent, males. Although we have not made an analysis of the cases observed in The Mayo Clinic, in our experience the idiopathic or spontaneous type of Raynaud's disease in the male sex is not common. If we eliminate the cases of vasomotor disturbances secondary to cervical rib, peripheral neuritis, thrombo-angiitis obliterans, and arteriosclerotic diseases, the percentage remaining which occurred in males is extremely small, less than 5 per cent; with increasing experience in diagnosis the percentage incidence in the male gradually has decreased. The average age incidence in Raynaud's disease, according to Monro's data, is 30.9 years for both sexes.

PROGNOSIS AND COURSE

The prognosis of Raynaud's disease is subject to wide variations. As far as is known, it never itself causes death; in our experience, death has been due to the consecutive or the subsequent development of an entirely different disease. The mild forms, with local syncope or mild grades of cyanosis in the digits, may not show change over a long period of years. We have observed many patients with a vasomotor disturbance for over 10 years who have not suffered actual pain or trophic lesions or progression of the disturbances of color. The duration of the malady is probably of importance in making a prognosis. In mild cases in which the condition has remained unchanged for a period of 2 or 3 years, the prognosis is usually good and reassurance may be the only advice necessary. For the most common type we have observed there has been gradual progression from the stage of syncope; more digits have become involved, perhaps the entire hand, and the condition has advanced into the stage of cyanosis or syncope has alternated with cyanosis. Then, after variable periods of time, there may be a gradual transition into a condition of chronic cyanosis of the extremities; recovery of the parts is less complete and when recovery does take place it is accompanied by excessive sensations of heat and excessive redness; sensitivity to environmental temperature becomes more acute and the paroxysms are induced with slight variations in temperature, even during the summer months. Pain, numbness, or dull aching during the period of syncope and cyanosis is the rule. Small, dry ulcers of the skin of the digits may appear. In this primary type of case, without complicating disease, the prognosis is not good from the standpoint of spontaneous cure. The condition usually persists, and while it does not progress to the point of serious gangrene, yet it constitutes a real disability to the patient. In the more rare forms, in which gangrene supervenes early in the course of the disease, prognosis is most grave from the standpoint of preservation of the digits. This type, in our experience, is most rare. In considering the prognosis, we believe that the important factor is the rate of progression of the disease during the first 2 or 3 years. It has been our experience that if at the end of this period trophic changes have not appeared, usually they do not appear. We have noted also that long periods of remission may occur in cases without known cause.

DIAGNOSIS

The diagnosis of Raynaud's disease is usually simple. Recalling the criteria laid down by Raynaud, the diagnosis rests on: (1) the presence of exaggerated vasomotor action as exhibited by changes in color, of symmetric distribution, in the extremities

and more rarely in the elbows, nose, and lobes of the ear, usually associated with discomfort, aching, or actual pain during the vasomotor paroxysms; (2) the existence of pulsations in the ulnar and radial arteries in the hands, and in the dorsalis pedis and posterior tibial vessels in the feet; and (3) predilection for the female sex. The age of the patient is also significant in diagnosis. We believe that the diagnosis of Raynaud's disease should not be made solely on the existence of vasospastic disturbances. The vasomotor phenomena following or complicating some disease, such as certain fevers and debilitating states, should not be considered true Raynaud's disease. Likewise, it is important to rule out all secondary forms of vasomotor disturbances, such as those observed when cervical rib is present, thrombo-angiitis obliterans, arteriosclerotic disease, peripheral neuritis, certain cases of epilepsy, and many other conditions. Changes in color of the extremities, and these alone, do not justify the diagnosis of Raynaud's disease.

ERRORS IN DIAGNOSIS

Our remissness in this respect has been due largely to the making of erroneous diagnoses of Raynaud's disease in the male sex. These patients, when traced over a period of years, have practically all given conclusive evidence of organic disease of the arteries; this has been particularly true in cases which later have proved to be instances of thrombo-angiitis obliterans. In this disease, in about 30 per cent of the cases, the initial symptom is vasospastic disturbance of the involved extremity. In about 15 per cent of this group, the palpable vessels revealed normal pulsation. Symmetry of the changes in color are usually lacking. If such patients are examined from year to year, closure of one or more arteries of an extremity frequently is found, or, more rarely, there may be evidence of occlusion in the digital arteries, with normal pulsations in the usually palpable arteries. This mistake has been made by us a sufficient number of times to make us extremely cautious in making a diagnosis of Raynaud's disease in a male. Buerger (11) and Allen and Brown have called attention to this frequent error in diagnosis, and a review of the literature indicates that there is a superabundance of similar errors.

In like manner the vasomotor disturbances occurring in older persons do not justify the diagnosis of Raynaud's disease. The cold, dead digit seen in cases of hypertension, arteriosclerosis, and occasionally in glomerulonephritis is a secondary form; it lacks symmetry and the multiple-phase color reaction necessary for the diagnosis of idiopathic Raynaud's disease. It is probably true that any organic disease of the vessels may be associated with vasospastic disturbances of the distal parts. The afferent impulses arise in the adventitial coat of the diseased vessels and initiate the necessary vasomotor reflex. Vasomotor color changes in scleroderma are extremely common; this has been pointed out by Raynaud, Monro, and recently by Brown and O'Leary. The last two authors, after studying the capillaries of the nail-fold disease, felt that probably there is a form of scleroderma in addition to the true or primary form. In this second form the changes in the skin are preceded for months or years by episodes of symmetric changes in color in the hands or feet, usually initiated by cold. The surface capillaries are quite characteristic of those observed in true Raynaud's disease. The changes in the skin may simulate closely those which occur in the early stage of true or primary forms of scleroderma. The distribution usually is limited, however, to the acral regions; the skin of the chest, upper arms, and face does not show the skin lesions, as they are observed in the primary forms. In this type of scleroderma, vasomotor reactions may occur with or following the sclerodermal process. The combination is quite common. Atrophy of the skin, pigmentation, deformities, and binding of the epidermis, indicate clearly that we are dealing with the true or primary form of scleroderma.

PATHOLOGICAL PHYSIOLOGY

The underlying disturbances which produce the changes in color are easily studied by microscopy of the capillaries of the nail-fold, and have been described by Mueller (30), Parrisius, and Brown. In the stage of pallor,

few capillaries are visible; the filling of the loops with blood is incomplete, and the capillaries have a segmented or broken appearance. The contained blood in the capillaries is static; blood is not observed entering the capillary loops from the arterioles. The collecting venules are usually invisible, or contain small amounts of blood. In the stage of cyanosis, blood is admitted into the capillaries both from the arterioles and by retrograde flow from the venules. The blood enters the capillary in the form of small segments. The capillaries become dilated, an increased number of them is visible, and the blood in the loops is stationary or flow occurs only after long intermissions. There is gradual deoxygenation of the capillary blood with increasing cyanosis. The capillaries may become greatly distended and may lose their characteristic shape. The collecting venules become dilated. With recovery, whether it is spontaneous or is induced by increasing the local or environmental temperature, the arterioles open, the flow of blood in the capillary loops becomes rapid, and the blood changes to a bright red color. The stage of rubor then is due to a large number of open capillaries and venules, many of which remain dilated to some degree and which contain red, oxygenated blood.

A summary of these studies corroborates in a striking manner the clinical deductions which have been made by Raynaud on this mechanism; that is, in the stage of pallor or syncope there is a spasm of the arterioles, capillaries, and venules, the degree of pallor depending on the completeness of the spasm. The stage of cyanosis is due to partial relaxation of the venules, with back flow of blood in the capillary loops; we have observed, also, concomitant opening of the arterioles; the relaxation is not complete enough to allow the resumption of the usual flow. All forms of gradations in behavior are noted in different cases; this amply explains the variations in color observed in certain subjects. Areas of moderate cyanosis may appear on one finger and in another deep cyanosis may remain; or, in one area of skin there may be recovery, with return to normal pink or rubor, and the surrounding skin may be cyanotic.

CALORIMETRIC AND THERMOMETRIC STUDIES

Subjects who exhibit vasospastic disturbances are especially prone to have decreased temperature of the skin with marked fluctuations in the involved parts. Under usual environmental conditions, room temperature 24 to 26 degrees C, the surface temperature is low in the hands and feet, ranging from 16 to 25 degrees C. The surface temperature of the extremities of the average normal person varies from 24 to 33 degrees C. In cases of Raynaud's disease, the fluctuations in surface temperature are extreme and constitute an exaggerated response to variations in the environmental temperature. This is shown, not only with determinations of the surface temperature by the thermocouple, but also in variations in the rate of heat elimination as determined by the foot and hand calorimeter. During the stage either of pallor or of cyanosis the surface temperature of the part becomes excessively low and increases with recovery to normal color. As the disease becomes more advanced, there is an increasing tendency for the surface temperature to remain low. The marked vasospastic element present in these cases also is shown in the response of surface temperature and in the rate of heat elimination when systemic fever is induced. For the purpose of studying the range of the vasomotor response, a procedure has been developed which gives us information on this point and serves as a useful index in determining the type of case amenable to operative measures. It is particularly valuable in cases of thrombo-angiitis obliterans which are frequently complicated by vasospastic disturbances. One of us (Brown) has devised what we call the "vasomotor or vascular index" which is determined as follows: Nonspecific protein fever is induced by the intravenous injection of triple typhoid vaccine, and the surface temperatures of the digits, foot, and hand, are taken simultaneously with the temperature in the mouth, or roughly simultaneously with the temperature in the blood. In all persons, including those who are normal and those with or without vascular disease, after a preliminary drop due to the chill, the temperature in the mouth and on the surface

rises. The magnitude of the rise in the temperature of the skin is dependent on (1) the initial temperature of the extremity, (2) the severity of the febrile reaction, and (3) the patency of the arteries. In cases in which the extremities are cold and in cases in which there is considerable vasospasm, the increase in the surface temperature is very great. The index is calculated by determining the rise in the surface temperature and subtracting from that the rise in the temperature of the mouth or blood; this, in degrees Centigrade, constitutes the change in temperature of the skin that is due largely to the shifting of blood that comes from vasomotor changes. This increase, divided by the number of degrees increase in the temperature of the blood, gives a figure which, in simple terms, indicates that for every degree rise in the temperature of the blood there is in the temperature of the skin a certain number of degrees' rise which is largely of vasomotor origin. In cases of Raynaud's disease, indexes of from 5 to 14 are obtained. In the cases of thrombo-angiitis obliterans with vasospastic disturbances, indexes of 2 to 6 have been found. This index is of practical importance in the selection of cases for operation, as the rise in surface temperature that comes with fever approximates roughly that occurring after sympathetic ganglionectomy (Figs. 1 and 2). It also has a certain diagnostic import in differentiating cases in which the diagnosis of a pure vasomotor disturbance and early organic disease of the arteries is not entirely clear. In arteriosclerotic disease of the limbs, the vasomotor indexes are low or zero. To obtain such an index militates against operation on the sympathetic system.

SUMMARY OF THE DISTURBED MECHANISM IN RAYNAUD'S DISEASE

Our studies give further corroboration of the theoretic explanation of the disturbance in this disease as formulated by Raynaud: there is overexcitability of the cerebrospinal vasomotor centers which explains the symmetric distribution of the disturbance, and agents which act on the periphery, as cold on the skin, can produce stimulation and overactivity of these centers. In subjects who exhibit vasospastic disturbances, there is exaggeration of the normal tonic activity of the vasoconstrictor mechanism. At first this hyperactivity is intermittent, requiring abnormally high degrees of stimuli to excite it; later it becomes more continuous and more disastrous. Excessive vasoconstriction of the peripheral vascular mechanism produces transitory closure of the arterioles, capillaries, and venules. The changes in color depend in a large degree on the completeness of the spasm. The recovery of the local circulation with the application of increased heat or with increased environmental temperature or in the presence of fever attests to the functional nature of the condition. The cause of the excitability of the vasomotor centers is unknown, but it is probable that, in some forms of vasomotor disturbance, the constitutional factor is paramount.

TREATMENT

The primary objects in the treatment of Raynaud's disease can be considered to be twofold: first, to remove, if possible, the exciting factors; second, to block, or to produce interference in, the vasomotor paths which supply the affected areas. In the cases of the mild types without pain or trophic disturbances, frequently considerable relief is obtained by protection from cold: changing of occupation, wearing of warmer clothes and warmer covering for the extremities—a factor in this age of limited female apparel—or migration to a warmer climate. Frequently, cases of the mildest types do not need treatment. If the condition is not progressive, if it does not produce serious symptoms, and if it merely is disturbing to the patient because of the changes in color, reassurance and mild degrees of protection may be all that is required. In the more severe conditions, in which the changes in color are more marked and less change in environmental temperature is necessary to cause the paroxysms, it has been our experience that the protective measures fail. We have advised a certain group of these patients to live in a warm climate, but the condition did not materially improve. It has been found that the variation between the warm day and the cool night gives rise to as severe symptoms as occur with the sharper variations in temperature in

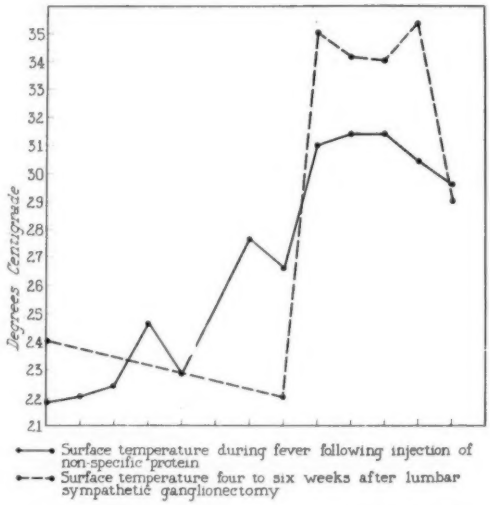


Fig. 1. Surface temperature of feet during fever and following lumbar sympathetic ganglionectomy. A close approximation may be noted.

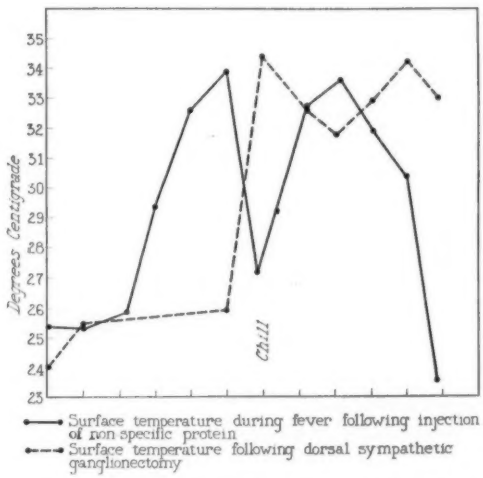


Fig. 2. Surface temperature of hands during fever and following dorsal sympathetic ganglionectomy. A fairly close approximation is shown.

northern latitudes. Occasionally we have noted considerable improvement following febrile reactions, induced by the use of non-specific protein. This can be explained perhaps on a basis of vasomotor paresis resulting from fever. Certainly in one case the color reactions, with the accompanying symptoms, became almost negligible following a short course of this form of treatment. In other cases we have not observed any effects whatever. The summary of the medical treatment in Raynaud's disease is that on the whole it has been most disappointing. The majority of cases, regardless of the institution of any of the foregoing measures, has continued to exhibit vasospastic reactions, and frequently have progressed to the initiation of mild trophic changes. The disease is a real disability, extremely disconcerting to the patient and most trying to the physician.

The second of the two objects in the treatment of Raynaud's disease, blockage of the vasomotor path to the part, has been the goal long sought in the treatment of this disease.

ANATOMY AND PHYSIOLOGY

Before discussing the specific innervation of the arteries to the upper and lower extremities, we could use a quotation from Ranson's article on "Anatomy of the Sympathetic Nervous System" so that the reader may obtain a brief but comprehensive review of its relationships.

The sympathetic nervous system is an aggregation of ganglions, nerves and plexuses through which the viscera, glands, heart, blood vessels, and smooth muscle in other situations receive their innervation. The most conspicuous feature of the system is a pair of ganglionated nerve cords or sympathetic trunks which extend vertically through the neck, thorax and abdomen. Each sympathetic trunk is composed of a series of ganglions bound together by short nerve strands. Every spinal nerve is connected with the sympathetic trunk of its own side by one or more gray rami communicantes through which it receives sympathetic fibers for the control of blood vessels, sweat glands, and smooth muscles of the hair follicles situated within the territory of its distribution. The majority of the nerve fibers taking origin in the ganglions of the sympathetic chain are distributed through the gray rami and the spinal nerves. The ganglions of the thoracic and abdominal portions of the chain are less concerned with visceral activity than with constriction of the peripheral blood vessels, erection of the hairs, and secretory activity of the sweat glands. But the upper thoracic and cervical ganglions bear a more intimate relation to the thoracic viscera, since they contain the cells of origin of postganglionic fibers for these viscera.

The thoracic and upper lumbar nerves are connected with the sympathetic chain by white as well

as gray rami communicantes. These white rami contain both afferent and efferent fibers. The latter take origin from cells in the gray matter of the spinal cord, travel through the ventral root and white rami, and enter the sympathetic system, to terminate in synaptic relation with the nerve cells found in the sympathetic ganglions. They are often designated as preganglionic fibers, while those that arise in the ganglions and relay the impulses onward are called postganglionic. The gray rami contain postganglionic fibers; the white rami contain preganglionic fibers.

The majority of the preganglionic fibers turn either upward or downward in the sympathetic chain and run for varying distances within it before ending in its ganglions. The cervical sympathetic trunk is composed exclusively of preganglionic efferent fibers, derived through the white rami from the upper thoracic nerves and ascending to terminate in the cervical sympathetic ganglions. The lumbar and sacral portions of the trunk are composed in the major part of descending fibers derived through the white rami from the lower thoracic and upper lumbar spinal nerves.

Those fibers of the white rami, which are concerned with the innervation of the abdominal viscera, pass into the splanchnic nerves and end in the cœliac ganglion. These fibers reach the splanchnic nerves after passing through the lower half of the thoracic sympathetic chain; but they are not interrupted in the chain ganglions through which they pass.

The sympathetic nervous system receives additional fibers from the spinal cord by way of the visceral branches of the third and fourth sacral nerves and from the brain through certain of the cranial nerves.

There are, then, these three streams of preganglionic visceral efferent fibers: (1) the cranial stream from the third, seventh, ninth, and tenth cranial nerves; (2) the thoracicolumbar stream, from the thoracic and upper lumbar spinal nerves by way of the white rami; and (3) the sacral stream from the second, third, and fourth sacral nerves. The cranial and sacral streams belong to what is commonly called the parasympathetic system.

Most of the sympathetic nerves contain, in addition to the fibers already discussed, also sensory fibers, which convey impulses from the viscera to the spinal cord. These sensory fibers have their cells of origin in the spinal ganglions and reach the sympathetic system by way of the white rami. Visceral reflexes, therefore, travel arcs of at least three neurons each. The impulses reach the spinal cord along visceral afferent fibers in the dorsal root and leave along preganglionic visceral efferent fibers in the ventral roots and white rami. These fibers end in sympathetic ganglions, and the impulses which they carry are relayed to involuntary muscle and glandular tissue by postganglionic fibers. The ganglions of the sympathetic trunk do not serve as reflex centers but only as relay stations in the conduction pathways from the spinal cord to the viscera.

Ranson and Edgeworth have been able, in a cat and a dog, to trace sensory fibers histologically, because of their relatively large size, through the sympathetic system from the cardiac plexus to the vagus and the three upper thoracic nerves. The fibers to the thoracic nerves were traced through the middle and the inferior cervical ganglia, sympathetic trunk, and corresponding white rami of the thoracic spinal nerves. However, they did not find any sensory fibers in the cervical sympathetic trunk above the middle cervical ganglion. They believe that it is fair to assume that in man a sensory distribution should exist similar to that which exists in these other mammals.

Kramer and Todd, in their study of the distribution of nerves to arteries of the arm, stated that, with the exception of the subclavian and axillary arteries which receive their innervation direct from the cervicothoracic ganglion, its origin corresponds with that of the nerve supply to the skin and muscle areas. Potts, in his study on the nerve supply to the arteries of the leg, came to the same conclusion. In the light of the results obtained by ramisection, section of the trunk, ganglionectomy, and of the anatomical descriptions of the innervation of the arteries of the extremities, we are compelled to believe that in the extremities the vasoconstrictor nerves, gray rami, and postganglionic fibers enter the spinal nerves and are given off at intervals corresponding with the somatic segments and that the arrangement here differs from that in the thoracic, abdominal, and cranial cavities, where the sympathetic innervation follows the vessels to their distribution.

Since we are interested in breaking these efferent vasoconstrictor impulses of all four extremities, we must make sure that the section in the lumbar area is high enough and that in the thorax it is low enough. Inasmuch as the second lumbar ganglion usually receives the last preganglionic, white ramus, it would be sufficient to divide the sympathetic trunk below this ganglion, but since the distribution of rami is not constant and since

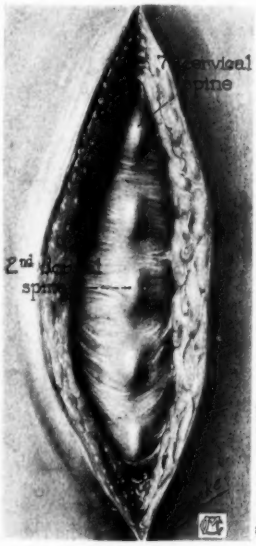


Fig. 3.

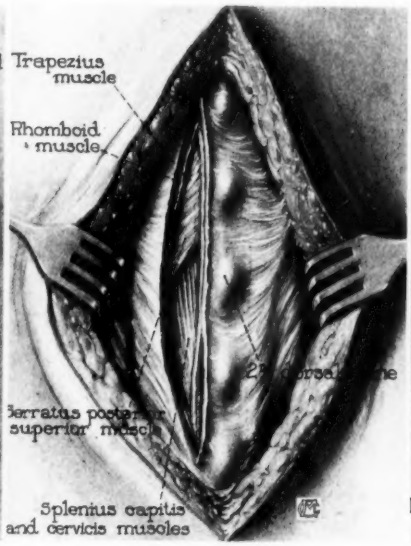


Fig. 4.

Fig. 5.

Fig. 3. Exposure secured by the dorsal median line incision.

Fig. 4. Incisions in fascia and muscle have been placed parallel with the spinous processes, thus exposing the various layers of the muscles which are encountered in uncovering the second rib and the transverse process of the second thoracic vertebra.

Fig. 5. Exposure of second rib and transverse processes of vertebræ by retracting the splenius capitis and splenius cervicis muscles.

there is a possibility of missing fibers, we prefer to resect the lumbar sympathetic trunk including the ganglia *in toto*, from above the second lumbar to a point below the fourth ganglion.

In the cervicothoracic area, it is important to include the second thoracic ganglion, for Kuntz has shown that both this sympathetic ganglion and the second thoracic spinal nerve, which carries vasoconstrictor fibers, contribute innervation to the lower trunk of the brachial plexus in a high percentage of cases. We grant that if one were sure of dividing all of the gray rami to the subclavian and axillary arteries and to the brachial plexus, one could preserve the trunk and ganglia, or could divide all the rami to the plexus and arteries, together with section of the trunk, but when the thoracic trunk is sectioned the cervicothoracic with all of the upper cervical ganglia are thrown out of work since they merely act as relay stations. Therefore, we again believe in a thorough resection of the second thoracic and the cervicothoracic ganglia and the intervening trunk in order to interrupt all vasoconstrictor impulses from the first and second thoracic ganglia directly to the first and second thoracic spinal nerves and arteries, in addition to interrupting efferent fibers which pass through the ganglia and trunk into the cervical ganglia to be distributed to the brachial plexus. It is true, this procedure will interrupt efferent impulses to the vasoconstrictors of all arteries in the neck and their corresponding distribution. It has and has not produced a complete Horner's syndrome with dilation of retinal vessels.

Since we are discussing the anatomy of the cervicothoracic ganglia, a few comments will be made on angina pectoris. Ranson stated that the white rami carry afferent and efferent impulses and that in the cat and the dog he and Edgeworth demonstrated sensory fibers passing from the cardiac plexus through the middle and lower cervical ganglia to the first, second, and third thoracic nerves. This means that these fibers must pass through the upper two or three thoracic ganglia and trunk, in

Fig. 6. Subperiosteal exposure of the second rib and its articulation with the transverse process of the second thoracic vertebra. The lines indicate the places where resection was done.

addition to the middle and inferior cervical ganglia, in order to reach the spinal nerves. Therefore, since so many operations on the cervicothoracic ganglia have failed to give relief in true angina pectoris, it is fair to assume that the operation was not complete and that some of the sensory fibers from the heart were not divided. According to Ranson, the sensory afferent impulses which reach the brain from the heart by way of the vagus probably rarely give rise to pain but expend themselves in the production of reflexes. The example he gives is the lowering of blood pressure on stimulation of the vagodepressor fibers which end in the arch of the aorta. Assuming that the surgical indications are suitable, that we are dealing with a true organic angina pectoris, and that the surgeon desires to be positive in the relief of the pain to the left side of the chest and the left arm, it will be necessary to carry out a more complete left anterior dissection or to adopt the posterior approach, with complete interruption of afferent fibers to the upper five thoracic nerves, by complete removal of the lower cervical and first and second thoracic ganglions. In a few instances, it may be necessary even to include the thoracic trunk and the fourth and fifth thoracic ganglions. One might choose to section these afferent sensory fibers from the heart through a laminectomy, which would be a procedure of less magnitude than a bilateral thoracic ganglionectomy would be. Of course, many of the patients suffering from angina pectoris are considered very poor surgical risks and therefore one naturally must follow conservative medical measures (paravertebral alcoholic injection) and resort to the more extensive operations only in severe cases.

It is our impression that the problem of angina pectoris might be approached surgically in two ways: the first, an attempt to relieve the vasoconstriction of the coronary arteries by sectioning the vasoconstrictor fibers entering the cardiac plexuses through the superior cervical cardiac nerve, which receives its efferent fibers from the superior cervical ganglion; the second, an attempt to interrupt the afferent pain sensations which are due, probably, to organic disease of the arteries and cardiac musculature and not attributable to vasoconstriction of the coronary arteries. The first of these two methods may bear a relation to the phenomenon present in Raynaud's disease and the second to the phenomenon of endarteritis obliterans of the extremities.

Davis and Kanavel presented a very good review of literature concerning the physiology of the vasoconstrictor phenomena of arteries and arterioles. It will suffice to say that the accepted opinions are that the gray rami from the thoracic or lumbar ganglia enter the spinal nerves as non-medullated fibers, are distributed according to somatic segments, and control to a great degree the tone of the arteries and arterioles and determine their size and caliber. Even though the vasoconstrictor nerve has been paralyzed, there still exists tone in the musculature of the artery. According to Bayliss, the tone is controlled by the vasodilator impulses which travel antidromically along the sensory fibers. Davis and Kanavel believe that it is just as fair to assume that the phenomenon of vasodilatation is not entirely dependent on the periarterial sympathetic innervation and that probably there is very little dependent on any such innervation of the blood vessel wall. They believe, fur-

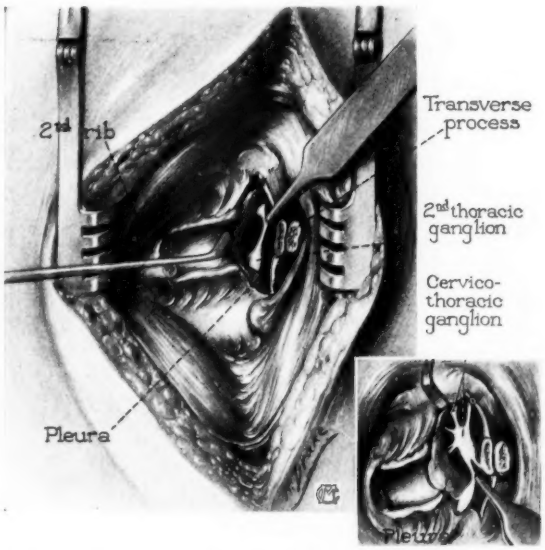


Fig. 7. Exposure of the second thoracic and cervicothoracic ganglia, with only a small portion of the cervicothoracic ganglion in the field. The method by which the second thoracic ganglion is elevated by traction preliminary to resection of the thoracic trunk below the ganglion is illustrated. The procedure is shown by which the cervicothoracic ganglion is drawn downward to expose the various communicating branches. In this particular case, the lower cervical portion of the cervicothoracic ganglion is separated from the thoracic portion by a dense band.

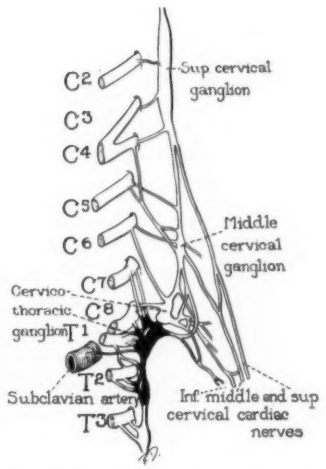


Fig. 8. The relations between the thoracic and cervical ganglia, the subclavian artery, and the cardiac plexus are shown. The darkened portion illustrates that section of the sympathetic trunk and the ganglia, which are definitely removed. Occasionally the cervical portion also may be removed.

ther, that it is equally as definite that these phenomena regularly are obtained through the agency of purely motor, purely sensory, or through mixed nerves of cerebrospinal origin.

From our clinical results, we are compelled to believe that the vasoconstrictor fibers play a tremendous rôle in producing the vasomotor spasms and that when they are cut, they prevent further spasm of the arteries and arterioles and permanently increased surface temperature is developed. It is rather difficult to explain the sudden disappearance of pain following resection of a sympathetic ganglion. It is possible, even in the lumbar area, that we divide afferent fibers in the gray rami on their return through the ganglia and white rami to the spinal cord, and that the arrangement in this area is somewhat similar to the sensory sympathetic arrangement described by Ranson for the cardiac plexus. However, we are more inclined to believe that the pain in the extremities in a large percentage of cases is relieved by improved peripheral circulation.

Probably Davis and Kanavel are partially correct, since the cerebrospinal motor nerves may act as auxiliaries to the vasoconstrictor nerves, and the sensory fibers may carry sensations of pain directly to the spinothalamic tracts of the cord.

OPERATIVE MEASURES

In the effort to relieve vasomotor spasm of the vessels in diseases that produced painful trophic and gangrenous changes in the extremities, Jaboulay is accredited with developing the operation of periarterial sympathectomy. The procedure did not gain much prominence until Leriche (26), in 1913, revived the operation and since has used it in a large and varied group of vasomotor disturbances. His endeavors have encouraged many surgeons to try the procedure. Although the operation of periarterial sympathectomy is local in its effect and has questionable

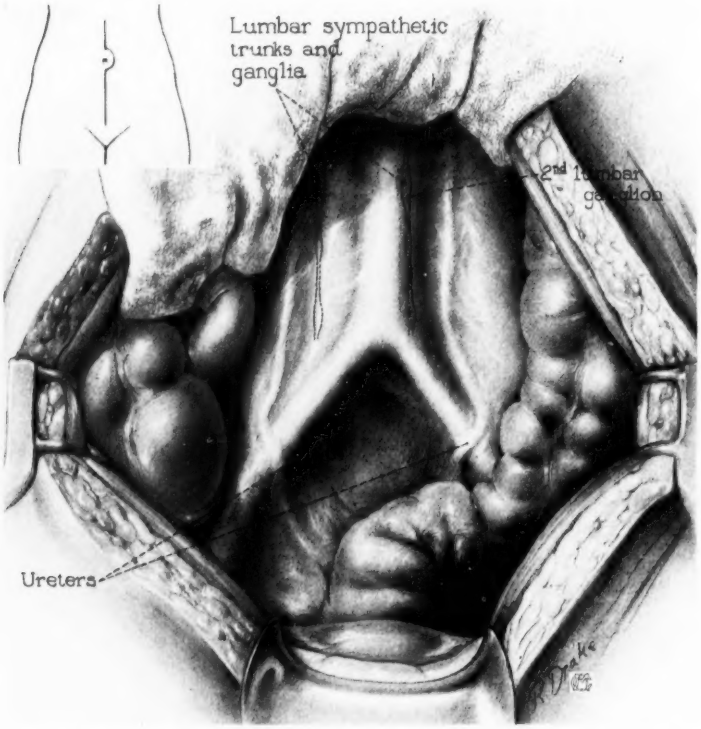


Fig. 9. The general topography of the lumbar area, and the relations between the vessels and the sympathetic trunk are shown.

evidence for its existence, since the nerve supply to the artery is segmental in its distribution, it is curious that Leriche (27), Muller (31), and many others have secured partial or complete cures following periarterial sympathectomy for Raynaud's disease, causalgia, and the healing of trophic, indolent ulcers, while others have met with failure or have obtained very incomplete, temporary results (8, 12). The conception that the vasoconstrictor nerves of the arteries may be paralyzed by dividing or removing the sympathetic innervation, as presented by Leriche, has stimulated other surgeons to develop more extensive operations. They have divided the gray rami, removed sympathetic ganglia, and divided the sympathetic trunks in order to interrupt postganglionic fibers before they enter the spinal nerves to be distributed to the various sections of arteries corresponding to the spinal nerve innervation.

Royle (37), in his report of January 26, 1924 on "The Treatment of Spastic Paralysis by Sympathetic Ramisection," made the comment, on examining the patient 6 hours after the operation, that he noticed that the right leg, the side operated upon, was brighter in color than the left leg, that it felt warmer and gave evidence of capillary dilatation. He, however, was unable to demonstrate any difference in temperature with an ordinary clinical thermometer.

From May 20, 1924, the date of our first abdominal transperitoneal lumbar sympathetic ganglionectomy for spastic paralysis, we have observed the same phenomena that Royle described, but we proceeded at once to measure these changes by the thermocouple

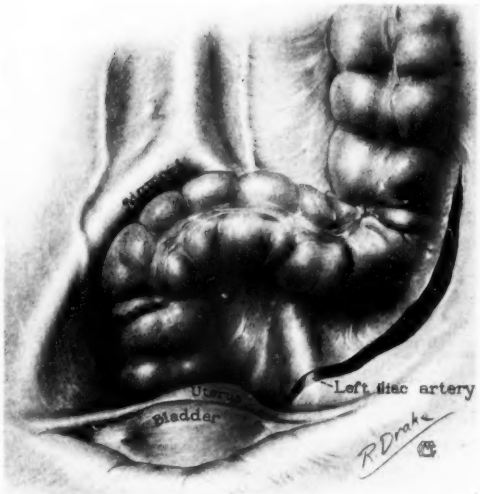


Fig. 10. The incision in the lower left posterior portion of the peritoneum is employed to reflect the parietal peritoneum, permitting elevation and retraction toward the median line of the sigmoid and descending colon.

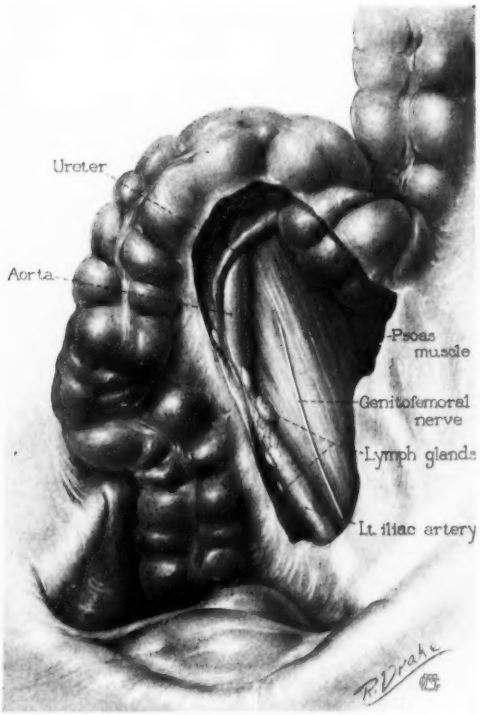


Fig. 11. Further elevation of the parietal peritoneum, retroperitoneal layers, and large bowel on the left side exposing the psoas muscle, the genitofemoral nerve, the abdominal aorta, and the common iliac artery previous to the exposure of the lumbar ganglia.

and the hand or foot calorimeter. When it became evident that the surface temperature of the feet remained elevated for months and when there was evidence that it would remain so permanently, we concluded that we would be justified in trying the procedure in a case of Raynaud's disease. This we did, March 19, 1925, and we (1) reported the case 3 months later. The relief of symptoms in the patient whose case was reported was so dramatic that we were almost afraid to believe our eyes. This patient and the other patients on whom we performed lumbar sympathetic ganglionectomy for Raynaud's disease have continued to be relieved following operation. Therefore, we confidently can say that the pain is relieved, the abnormal color reactions disappear, the feet and legs present a pinkish color, are dryer and definitely warmer than before operation, and there is an average sustained increase in surface temperature of 12°C.

Diez, in 1925, advocated for trophic and gangrenous conditions resection of the lumbosacral cord, removing the second lumbar ganglion and the ganglia and trunks down to and including the third sacral ganglion. He reported that he carried out this procedure for the first time, July 24, 1924. Diez and we were quite unaware of the fact that in our separate ways we were trying to accomplish the same result in a rather similar way. Royle's criticism of our periarterial neurectomy of the common iliacs in conjunction with the operation on the sympathetics is justified, and that phase of the operation was dropped before his criticism appeared in print. It was originally employed to make the operation more complete, thus not only interrupting the postganglionic fibers to the spinal nerves but also breaking sympathetic fibers to the iliacs from the pelvic plexus. However, we soon learned that if on one side we did unilateral periarterial neurectomy in addition to lumbar sympathetic ganglionectomy and on the

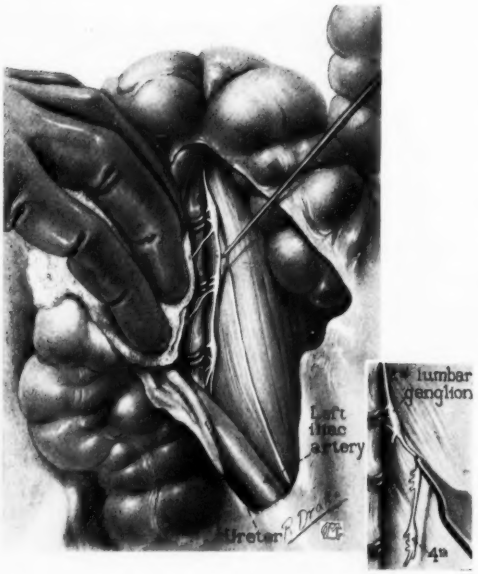


Fig. 12. Exposure and resection of the left lumbar sympathetic trunk, with the second, third, and fourth lumbar ganglia.

other side did lumbar sympathetic ganglionectomy alone the changes in the surface temperatures on the two sides were the same. We agree, also, with the criticism that it is unnecessary to remove the lumbar ganglia if all of the postganglionic fibers are divided below the second lumbar ganglion. However, since the distribution of the gray rami from the lumbar ganglia is not constant, and since we want to interrupt efferent fibers to the sacral ganglia, we feel more confident that the operation is nearer perfect and that the interruption of efferent impulses is more complete when we resect, entire, the second, third, and fourth lumbar ganglia with the intervening trunk. The same criticism made on our extensive operation may also be applied to Diez' operation, which includes the sacral ganglia, also of Royle's ramisectomy in addition to section of the sympathetic cord. If he were sure of dividing all postganglionic fibers by dividing the sympathetic trunk below the second lumbar ganglion, he would not have to divide the rami to the lumbar ganglia; for it is generally accepted that the lowest pair of preganglionic fibers (white rami communicantes) enter the second lumbar sympathetic ganglia.

So far, we have not seen any untoward results from the removal of the lumbar ganglia. Davis and Kanavel, June 20, 1926, presented a very comprehensive study on sympathectomy in Raynaud's disease, erythromelalgia, and other vascular diseases of the extremities. They reported on five cases but completely on only two. One of these two was a case of erythromelalgia of the feet, in which operation was done April 29, 1925. In this case they employed the abdominal transperitoneal approach, which they first described in the same general discussion on lumbar ramisectomy wherein we described our abdominal approach to the lumbar sympathetics. The occasion of this discussion was the meeting of the Clinical Congress of the American College of Surgeons in New York in October, 1924, following addresses by Royle (37) and Hunter. The second case reported by Davis and Kanavel was a true case of Raynaud's disease of the upper extremities in which operation was done, January 29, 1926, and the right cervical sympathetic chain and stellate ganglion were removed. The postoperative notes and color plates raise two points worthy of discussion. In the first case, that of "erythromelalgia," there is presented a history and color changes similar to those which occur in thromboangiitis obliterans and the patient responded postoperatively very much as many patients with thrombo-angiitis obliterans whom we have seen. The fact that the dorsalis pedis and posterior tibial arteries were palpable and open, naturally suggested the diagnosis of erythromelalgia, but occasionally we see patients with early symptoms of thromboangiitis obliterans, in whom there is involvement of the peripheral arteries distal to the point where we are able to palpate the dorsalis pedis and the posterior tibial arteries. In thrombo-angiitis obliterans there exists frequently a vasomotor spasm of the collateral arteries in conjunction with the organic lesion, which may be relieved by interrupting the efferent fibers to the vessels but which does not apparently alter the thrombotic process. Hence ganglionectomy or ramisectomy with section of the sympathetic cord should be

Fig. 13. The incision on the right side, similar to that on the left side which is illustrated in Figure 8.

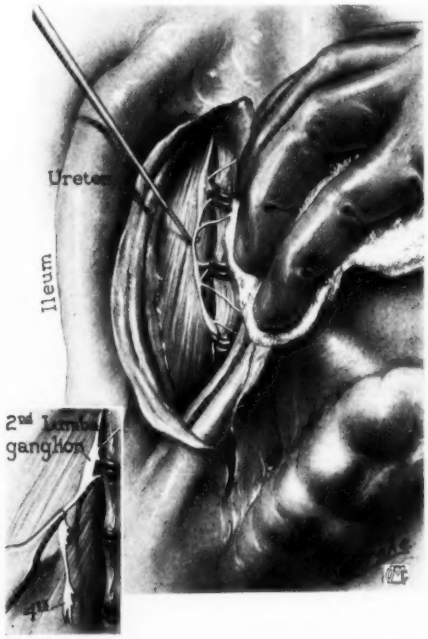


Fig. 14. Exposure and resection on the right side, similar to that on the left side which is illustrated in Figure 10.

employed in patients with a vasomotor spasm which is capable of relaxation by fever that is induced by the injection of foreign proteins. It should be employed, also, in patients with more or less quiescent thrombotic processes. In the second case reported by Davis and Kanavel the color plate illustrating the condition following the cervicothoracic ganglionectomy suggested an incomplete result. With an incomplete result cyanosis would recur in distal parts of the phalanges, and in the illustration there was cyanosis in this region. Incompleteness is common with the operation as it is carried out through the anterior approach. We achieved the same result in a patient on whom we operated for Raynaud's disease of the upper extremities, March 2, 1925. We never have succeeded in securing so perfect a result with the cervicothoracic ganglionectomy by the anterior approach as we did with the lumbar ganglionectomy in the treatment of Raynaud's disease, all of which means that the efferent fibers to the blood supply of the arm and hand were incompletely divided. Our own experience and the reports of others aroused us sufficiently finally to adopt a posterior intrathoracic approach and this is successful.

Royle (38), in 1927, reported on eight patients operated on for vasomotor disturbances: four had Raynaud's disease and four, thromboangiitis obliterans. The results confirm the study of temperature changes already given.

Fulton, in 1928, presented a very thorough study of a patient with Raynaud's disease. The disease was bilateral and involved the hands as well as the feet. In order to have controls, only one side was operated on. On the right side, the Royle cervicothoracic ramisectomy was performed and was followed immediately by a Royle ramisectomy of the right second, third, and fourth lumbar ganglia in conjunction with division of the lumbar sympathetic trunk. Fulton's studies on this patient, over a period of one year, demonstrated complete relief of symptoms in the

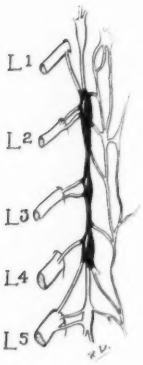
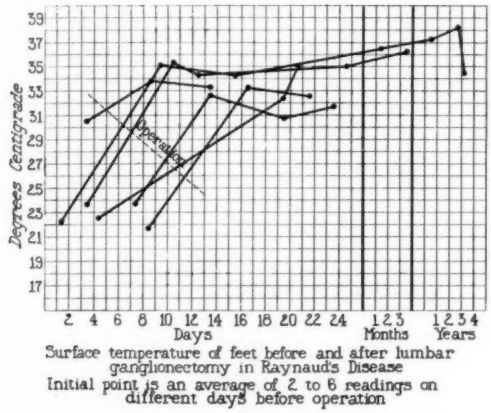


Fig. 15. The dark portion illustrates the section of the lumbar trunk and the ganglia that are removed in the treatment of Raynaud's disease of the lower extremities.

right foot and leg but no relief of symptoms in the right upper extremity. His experience was in absolute accord with our experience in the treatment of Raynaud's disease until we began to use the posterior intrathoracic approach to the upper two thoracic ganglia. This permits us to resect the second thoracic and the cervicothoracic ganglia and the intervening trunk. In this way, we believe we interrupt completely all efferent vasoconstrictor impulses to the vessels of the upper extremities, which gives us the same result that previously was obtained by lumbar sympathetic ganglionectomy.

Before proceeding with the description of the surgical technique used by one of us (Adson), it might be of interest to review briefly the history of the cervicothoracic ganglionectomy as carried out through the anterior approach. Jonnesco called attention to the fact that resection of the stellate ganglion (which is the cervicothoracic) with or without resection of the middle and upper cervical ganglia, first was done in 1896 for epilepsy and exophthalmic goiter; later, by other surgeons for migraine and glaucoma. In 1906, Jonnesco followed a suggestion made by Francois Frank and performed his operation for the relief of angina pectoris, which was successful. From that period until recently the operation has been used by scores of surgeons for almost every conceivable ailment of the head, neck, and upper extremities. The frequent relief of angina pectoris by resection of the cervicothoracic ganglion has justified this procedure.

Fig. 18. Appearance of patient 14 days after right dorsal ganglionectomy. Contraction of the pupil of the right eye and absence of sweating on the right side of the forehead are shown.



Surface temperature of feet before and after lumbar ganglionectomy in Raynaud's Disease
Initial point is an average of 2 to 6 readings on different days before operation

Fig. 17. Increases in the surface temperature of the feet in six cases of Raynaud's disease. The permanent nature of the increase is shown in the case in which observations have been made over a period of 3 years.

This discussion does not permit a review of the surgery of angina pectoris. In 1923, Bruening resected the cervicothoracic ganglia for Raynaud's disease and for scleroderma. Davis and Kanavel, in 1926, presented a very thorough review of the anatomy and physiology concerning the vasoconstriction seen in Raynaud's disease and included drawings illustrating the technique used by them. But again if we are to judge by comparison of color plates before and after operation, the anterior approach, with resection of the stellate ganglia, was insufficient completely to interrupt all

efferent sympathetic fibers to the vessels of the finger tips.

In 1928, Royle (39), in a treatise on section of the sympathetic trunk for Raynaud's disease and spastic paralysis, reported a case of Raynaud's disease of the upper extremity in which he had performed, 2 years previously, a Royle ramisection. This had been without success and then he had reoperated through the new approach, which differs from that of Jonnesco.

Royle reflects the clavicular attachment of the sternocleidomastoid and divides the tendinous attachment of the scalenus anticus in order to secure better exposure of the stellate ganglion; then he divides the thoracic trunk below the cervicothoracic ganglion with satisfactory results. On the other side, a month later, he resects the thoracic trunk, with successful results. These operations were performed May 24, 1928, and July 3, 1928. We feel sure that his latest suggestion has offered the best anterior approach to the cervicothoracic ganglion. We are familiar with this field, as we have used this approach and have described it previously in connection with the treatment of the symptoms arising from the presence of cervical ribs. We agree, with Royle (39) also, in his statement that work in this surgical field is fraught with dangers and that previous failures were due to incomplete operations. However, we disagree with him in his satisfaction with section of the thoracic trunk below the stellate ganglion, for Kuntz has shown that the second thoracic ganglion contributes gray fibers to the first thoracic spinal nerve, as well as to the second thoracic spinal nerve, and this, in turn, often contributes to the lower trunk of the brachial plexus. We have been able, also, at the operating table, working through the posterior intrathoracic approach, to substantiate Kuntz' findings.

It pleases us that Royle (39) recognized the importance of section of the trunk. We have advocated it right along in our lumbar sections and again in the procedure which we (2) have developed recently in effecting complete interruption of efferent sympathetic fibers to the subclavian and axillary arteries and to the brachial plexus.

All of the more or less partial or incomplete results in the treatment of vasoconstrictor disturbances of the upper extremities when sections of the stellate ganglion were done by the anterior approach convinced us that some other approach was necessary. Royle's recent operation offers one solution, but we were unaware of his new procedure when, July 31, 1928, we first resected the second thoracic and cervicothoracic ganglia and the intervening trunk, through the posterior intrathoracic approach. We did not receive Royle's (39) reprint until 3 months later.

Therefore, the problem that confronted all of us was to find a procedure that would permit complete removal of the second thoracic and cervicothoracic sympathetic ganglia and the intervening trunk, in order completely to break all sympathetic impulses to the subclavian and axillary arteries and to the brachial plexus. It appeared that the posterior approach was the logical procedure and was the method we believed necessary when we failed in our first attempt to relieve Raynaud's disease of the upper extremities. The rami from the ninth, tenth, eleventh, and twelfth thoracic ganglia had been sectioned through a dorsal approach, for a neuropathic condition of the abdomen, by von Gaza in 1924. In groping about in medical literature for information concerning the exact anatomy of this field, our attention was called to Henry's essays on "Exposure of Long Bones and Other Surgical Methods." One of these essays was on an anatomical dissection of the cervicodorsal ganglion from the posterior approach and had the title "A New Method of Resecting the Left Cervico-Dorsal Ganglion of the Sympathetic in Angina Pectoris." This evidence was sufficient to convince us that we could resect the second thoracic ganglion, the cervicothoracic and the intervening sympathetic trunk, and thus we could completely interrupt all of the efferent fibers to the vessels of the arm as well as those to the head and neck. In our first case, the procedure was divided into two operations: resection of the second thoracic ganglion, the cervicothoracic ganglion, and the intervening sympathetic trunk on right side, July 31, 1928, and on left side, September 11, 1928.

Inasmuch as it was necessary to perform bilateral operations, we had to depart from Henry's suggestions concerning skin and muscle flaps. Furthermore, in accordance with Kuntz' anatomical suggestion, we believed it necessary to include the second thoracic ganglion and rami. Therefore it was necessary to enlarge the scope of the operation, and this would be necessary too, probably, if one were to break all afferent impulses from the heart to the brachial plexuses in order to relieve all referred pain to the arms and chest wall.

SURGICAL TECHNIQUE FOR THE REMOVAL OF THE UPPER THORACIC GANGLIA

After the patient is anæsthetized, he is placed in the prone position, on two soft pillows. The arms are permitted to hang down over the edge of the table to allow retraction of the scapula outward and forward. The neck is flexed forward and the head is supported by an Adson-Little cerebellar head rest. Ether is administered by the inhalation method, with an open mask attached to the head rest. The incision in the skin is made in the median line, from the tip of the sixth cervical spine to the tip of the fourth dorsal spine. The incision is carried down to the spinous processes, thus exposing the fascia over the trapezius on both sides. The fascia-muscle incision is made on each side, and parallel with the spinous processes, extending from the seventh cervical vertebra to the fourth dorsal vertebra. The procedure at this point is carried to completion on the side to be operated on, before muscle dissection on the opposite side. The fascia-muscle incision is made first through the tendinous attachment of the trapezius to the spinous processes, and subsequently through the spinous attachment of the rhomboids and serratus posterior. Then, use of a retractor exposes the erector spinæ group and the lower end of the splenius cervicis. The transverse processes of the dorsal vertebræ can be palpated through these muscles. After one has made sure that the spinous process of the second dorsal vertebra has been identified, as well as the tip of the transverse process of the second dorsal vertebra, a blunt dissection is made through the erector spinæ group, parallel with the spinous processes. The retractor is replaced at a deeper level and opposite the transverse process of the second dorsal vertebra. Muscular attachments to the transverse process are now freed mesially until one can demonstrate the process where it fuses with the body and the lamina. The periosteum of the rib is incised on its dorsal aspect. This permits exposure of the rib lateral to the transverse process for a distance of 3 centimeters. The rib is cut at the outer border of this area of exposure and the transverse process is cut where it joins the body of the vertebra. Occasionally one may have difficulty with the intercostal artery, but this can be ligated, care being taken not to injure the first or second thoracic nerves. The pleura and lung are now gently dissected from the lateral side of the vertebra and are retracted anteriorly and laterally. This procedure, in turn, will expose the sympathetic trunk between the second thoracic and the cervicothoracic sympathetic ganglia; the trunk lies at a level corresponding to the articulation of the head of the second rib. After exposure of the sympathetic trunk, the procedure consists in the dissection and the removal of these ganglia and the intervening trunk, elevating and resecting the second thoracic ganglia, dividing any gray rami that may run laterally from the second thoracic ganglia to the first thoracic nerve. After the second thoracic ganglion has been elevated and the sympathetic trunk has been divided below, traction on the sympathetic trunk is now made from above downward, thus exposing the cervicothoracic ganglion. This exposure is done by first dividing the ansa-subclavian ramus, and subsequently dividing the rami as they pass off to the first thoracic spinal nerve. These maneuvers permit gradual mobilization of the ganglia of the thoracic chain and finally retraction of the cervicothoracic ganglion sufficiently to divide all of the rami ascending from the ganglia into the cervical region (Figs. 3 to 8).

SURGICAL TECHNIQUE FOR REMOVAL OF THE LUMBAR GANGLIA

The incision is made from the symphysis to a point 5 to 7 centimeters above the umbilicus,

between the rectus abdominis muscles and to one side of the umbilicus. The sheath of the rectus muscle subsequently is opened on each side below the umbilicus and, on the left side, above the umbilicus, facilitating closure along anatomical lines. If the abdomen is extremely flaccid, it may be advisable to make an overlapping closure (C. H. Mayo type) in the external leaves of the fascia of the rectus abdominis. Before the peritoneum is opened, the patient is lowered from the horizontal position to the Trendelenburg position, thus insuring better exposure of the lumbar sympathetic ganglia. Although general exploration may reveal other abdominal lesions, they are not disturbed at this time since it is desired to avoid the additional risk of contamination. The intestines are packed upward, as they are when hysterectomy is done. It is immaterial whether the ganglia are approached first on the right or on the left side. Usually, the ganglia of the right side are more difficult to approach because of the intravertebral veins which run anteriorly and across the sympathetic trunk. To elevate the inferior vena cava is more difficult than to elevate the abdominal aorta and the common iliac artery on the left.

In the exposing of the left lumbar sympathetic chain, it is necessary to loosen and elevate the sigmoid and the lower portion of the descending colon. This is done by incising the peritoneum superior and just lateral to the anterolateral border of the upper portion of the sigmoid and the attachment of the lower portion of the descending colon. When the line of cleavage is once started, the large bowel can be elevated readily and can be retracted, with the posterior wall of the peritoneum, beyond the median line. This exposes the retroperitoneum, the ureter (as it courses over the bifurcation of the common iliac), the left common iliac artery and vein, the lower end of the abdominal aorta, the genitocrural nerve (which perforates the psoas muscle), the psoas muscle, the lumbar vertebræ, the lymph nodes, and the lumbar sympathetic ganglia, trunk, and rami which lie on the lumbar vertebræ, just mesial to the psoas muscle. The ureter on the left side is more easily retracted mesially than laterally. With a moist sponge it is held gently, together with the colonic mesentery, the upper end of the sigmoid, and the lower end of the descending colon, in position in the median line. The abdominal aorta is elevated and is retracted mesially, by traction with a finger on a gauze sponge. It is held by an assistant. The sympathetic ganglia, trunks, and rami are then dissected free by a wet cotton ball dissector held in thumb forceps. It is well to begin at one or the other end of the lumbar sympathetic chain. On the left side, it is preferable to expose the fourth lumbar ganglion at the brim of the pelvis and to divide the sympathetic trunk below it. All of the rami, including those to the spinal nerves, the hypogastric plexuses, and the aortic plexuses, are then divided. The dissection is then carried upward to include the third and second lumbar sympathetic ganglia. Undue traction should not be exerted on any of the tissues handled, especially the mesentery leading to the sigmoid and colon, so as to avoid the possibility of rupture or thrombosis of arteries or branches of arteries which supply the large bowel.

The approach to the lumbar sympathetic ganglia on the right is similar to that on the left, except that the peritoneal incision is made just lateral to the right lateral border of the abdominal vena cava, and is carried downward over the right common iliac vein into the true pelvis, upward and mesially along the root of the mesentery of the small intestine, partially across the vena cava for a distance of 15 centimeters from the brim of the pelvis, and downward into the pelvis for a distance of 5 to 7 centimeters. The cæcum, the small intestine, and the ureter are retracted outward and upward. The vena cava is retracted mesially, and the common iliac vein, downward and mesially. In the posterior wall of the peritoneum, just above the brim of the pelvis on the right side, several small veins may be encountered which can be divided and ligated. The further exposure and the removal of the lumbar sympathetic ganglia and division of all of the rami and the sympathetic trunk are similar to the procedures employed on the left side. However, the fourth lumbar sympathetic ganglion on the right side usually lies underneath the

TABLE I.—SURFACE TEMPERATURE PRECEDING AND FOLLOWING LUMBAR SYMPATHETIC GANGLIONECTOMY

Case	Sex	Age	Date	Temperature, Degrees Centigrade									Comment
				Mouth	Room	Right				Left			
						Thigh	Leg	Foot	Toes	Thigh	Leg	Foot	Toes	
1	F	16	3-18-25	37.2	22.0	33.7	31.5		30.5	35.1	32.4		31.2	Feet cool and cyanotic.
					22.0	36.0	34.4		30.5	34.3	32.1		31.2	
			3-19-25											Lumbar ganglionectomy.
			3-24-25		22.4	34.5	34.9		33.6	34.2	34.5		34.2	
			3-30-25		22.8	33.4	32.2		33.1	33.0	33.4		35.5	Feet warm and dry.
			4- 6-25		22.0	32.8	29.5							
2	F	25	10- 2-25	37.0	22.7			28.2	25.0			27.8	24.1	Feet cold, swollen, and cyanotic.
			11- 5-25	36.6	22.3						29.4	24.7	22.1	
			11- 7-25											Lumbar ganglionectomy.
			11-14-25	37.4	22.0		30.9	33.7	34.5				35.0	
			11-21-25	37.1	22.0	36.4	34.6	34.8	35.3	34.0	34.3	34.5	34.2	Feet warm and dry.
			11-23-25	37.0	22.4					31.7		33.0	34.0	
			1-19-26	36.6	23.0	35.2	35.3	35.6	36.3	35.4	34.8	35.8	36.6	
			2- 1-27	37.0	22.2						32.0	35.4	36.0	Feet show no decrease in temperature during cold days; look quite normal.
			1-26-28		22.2			36.0	37.3			37.2	37.4	
			6-11-28		23.0		30.1	32.5	34.5		31.9	33.4	34.0	
3	F	22	6- 4-26	36.7	23.0		33.0	31.8	31.1		33.5	32.5	29.3	Marked vasomotor mottling of feet and legs.
			6- 7-26	37.0	23.0		29.9	28.3	24.3		31.0	30.5	23.9	
			6-12-26											Lumbar ganglionectomy.
			6-14-26			35.2	34.8	35.5	35.7	35.2	34.8	35.6	35.2	
			6-16-26			34.7	33.8	33.6	33.3	35.2	33.8	34.7	33.3	Feet warm and dry.
			6-29-26	37.1	26.0		33.8	34.3	35.0		33.3	34.5	35.0	Normal color; legs show a few mottled areas; no relief from pain in feet.
			9-29-26	37.1	26.0					36.0	35.5	35.7	36.1	
4	F	30	10-13-27	37.0	22.6		29.4	26.4	23.4			26.4	23.4	Feet cold and cyanotic; sclerodermal changes in skin.
			10-14-27	37.2	22.2		27.4	27.3	21.4			27.3	22.2	
			10-17-27											Lumbar ganglionectomy.
			11- 2-27	36.8	23.0		32.6	31.8	33.2		33.3	33.0	33.2	Feet warm, dry, and no color changes.
			11- 3-27	37.0	23.4			33.0	35.0			35.0	32.8	
5	F	25	10-11-28	36.8	22.5	32.7	32.7	32.3	31.3	32.6	32.1	31.6	31.2	Feet hot, red, and sweating.
			10-13-28	36.8	22.5	29.9	27.5	25.1	20.3	28.6	25.4	25.0	20.1	Cold, cyanotic feet at ordinary room temperature.
			10-15-28	37.0	20.3		28.6	26.1	23.4		28.6	26.1	23.3	
			10-17-28	37.0	22.0	30.0	28.7	24.0	19.9	29.6	27.7	24.5	20.2	
			10-18-28	37.2	21.0	30.7	30.0	27.5	25.0	27.1	29.3	27.8	26.0	
			10-23-28											Lumbar ganglionectomy.
			11- 5-28		22.3	31.3	31.5	32.1	32.7	31.0	31.2	32.1	32.1	Feet dry and markedly warm.
			11-12-28		19.9	31.2	30.0	29.5	30.9	31.0	29.3	30.0	30.5	Pulsation in dorsalis pedis excessive.
			11-15-28	37.0	24.0		29.9	29.2	30.2		29.4	29.8	30.5	Feet normal.
			11-17-28		23.5		29.8	30.2	31.9		30.1	30.0	31.8	Very dry.
6	F	31	4- 1-28	37.1				27.7	25.5			27.0	25.1	Marked cyanosis.
			5- 1-28	37.0	22.0			28.9	15.0			20.1	14.5	Excessively cold feet.
			10- 2-28											Lumbar ganglionectomy.
			10- 8-28	37.1	21.0						29.6	30.2	25.8	
			10-17-28		22.0		30.9	33.7	33.2		29.7	32.4	31.6	
			10-23-28		20.5		28.6	31.1	32.5		29.6	31.1	32.8	Feet normal, dry, and warm.

intravertebral vein and not superficial thereto, as it does on the left side.

The closure consists in accurate apposition of both retroperitoneal incisions to prevent retroperitoneal hernia and accurate closure of the abdominal wall to prevent the more common type of postoperative hernia (Figs. 9 to 15).

EFFECTS OF LUMBAR GANGLIONECTOMY IN SIX CASES OF VASOMOTOR DISTURBANCES OF THE SPASTIC TYPE, RAYNAUD'S DISEASE AFFECTING THE FEET

CASE 1. The patient was a Russian-Jewish schoolgirl, aged 16 years, who for the last 8 years had noticed that during the cold weather the feet became white, then intensely cyanotic and swollen. Associated with these symptoms was pain which radiated from the feet to the knees and had increased in severity in the last 2 years. Pulsations were present in the vessels of the feet, with the exception of the left dorsalis pedis; the absence of detectable pulsations in this artery was due, we thought, to swelling of the tissues. During the attacks, there was definite swelling of the feet, which in the last few months had remained continuously. There was no evidence of diminished circulation when the feet were elevated. Ulcers were present over both malleoli and on the fifth right toe. The diagnosis was Raynaud's disease, of fairly advanced type. Lumbar ganglionectomy was carried out, March 19, 1925; following this the feet became hot and dry, with excessive scaling of the plantar surfaces. The ulcers healed within 10 days and the pain entirely disappeared (Table I). A report from the patient one year later stated that the feet remained hot and dry, had a normal appearance and, with the exception of a little swelling at the back of the heel, she felt that the feet were quite normal. She stated that there had been mild symptoms of a similar disturbance in the hands.

CASE 2. The patient was an American, aged 25 years, a school teacher, who for 6 years had had a gradually progressing change in color of the hands and feet. For the year preceding admission to The Mayo Clinic, the color changes in the feet were so profound and the condition so painful, that during the winter months it was impossible for her to remain outdoors for any length of time. On examination, pulsation in all the palpable vessels of the hands and feet was diminished but present. At ordinary room temperature, there was extreme cyanosis of the feet associated with marked, continuous, dull, aching pain. Lumbar ganglionectomy was carried out November 7, 1925. There was no pain along the sciatic nerve or hyperæsthesia of the skin in the legs after the operation. Since this patient lives in Rochester, she has been carefully observed for a period of 3 years. During this time her feet have remained warm and dry, and the abnormal color reactions have entirely disappeared. Chilling of the body does not produce appreciable change in the surface temperature of the feet. There has been maintained relief of the condition in the feet for the three-year period of observation (Table I). The disease in the hands gradually had progressed in spite of the fact that left cervical ganglionectomy and perivascular neurectomy on the axillary artery had been done. Following the successful results of dorsal ganglionectomy in Case 5, a similar procedure was carried out on this patient and the results are described in the subsequent pages.

CASE 3. This patient was aged 22 years, a clerk, who entered The Mayo Clinic, May 21, 1926. The history of her trouble dated back more than 5 years. Following an attack of influenza, she had appendicitis and operation was followed by infection of the wound. Every summer following this, her feet would become swollen, and the normal contour of the ankles would be lost. During the cold weather she had attacks of cyanosis and coldness in the feet; there was no history of blanching. Her subjective complaint was of burning, worse in the summer but not clearly associated with increased surface temperature of the feet, and coldness and lividity during the winter months, associated with dull, aching sensations. At examination the patient was found to be a well-nourished young woman with patchy, livid areas in the skin of the feet, ankles, and calves, bilateral and fairly symmetric. A sharp decrease in surface temperature was appreciable in the middle of the legs, and the temperature rapidly diminished to the distal portions of the feet. The fingers were cold, but there were no color changes with varying temperatures. The subjective symptoms had reached such a degree that it constituted a disability. The vessels of the feet and hands were open, with apparently normal pulsations. The neurologic examination was essentially negative. The diagnosis in this case was not entirely clear; phlebitis, chilblains, and a spastic atypical, vasomotor disturbance were considered. The thermometric studies showed that the areas of lividity had a surface temperature of 1 to 1.5 degrees Centigrade less than the surrounding skin. In response to injections of nonspecific protein there was a sharp increase in the surface temperature and a fairly high vasomotor index. During the height of the febrile reaction she complained of burning in the feet. The final diagnosis was that of vasomotor neurosis of the spastic type associated with non-pitting œdema and atypical pains in the feet. Operation was carried out, June 12, 1926; bilateral lumbar ganglionectomy was done. One month later, examination showed increased pulsations of the vessels and the feet were warm and dry, associated with mild symptoms of burning. The areas of lividity still persisted in the lower part of the leg but had entirely disappeared from the feet. The measurements of the extremities showed a decrease since operation of 3 centimeters in the circumference of the calf and 2 centimeters in the circumference of the ankle. Table I shows the increases in the surface

temperature. Four months later the patient stated that the subjective complaint in the legs was unchanged. Re-examination by Dr. Fopeano at the University of Michigan in June, 1927, showed that her legs were still swollen from the ankles to the knees, and that the skin was warm and red, and some areas of induration were present beneath the skin. A further report from the patient, July, 1927, stated that she was still having trouble with her legs and that there were small inflammatory areas on each leg. The results in this case are not satisfactory and we are not at all clear as to what is the diagnosis. It is evident that a vasospastic disturbance was present but probably this did not produce the symptoms of which the patient complained. The subsequent history, as obtained through letters, seems to point more to some inflammatory condition, perhaps lymphangitis or erythema nodosum. Irrespective of the clinical results obtained in this case, the operation accomplished vasodilation of the vessels of the feet, with the disappearance of the abnormal vasomotor reactions. Relief from symptoms was not obtained and this was due, we believe, to an incorrect diagnosis. The vasomotor disturbances were not responsible for the symptoms.

Case 4. A woman, aged 30 years, a clerk, entered The Mayo Clinic May 16, 1927. Following tonsillectomy 5 years previously she noted that both hands became numb and deathly white to the metacarpophalangeal joints. These attacks would occur at intervals of every 2 or 3 days. The attacks were initiated by cold and were prevented by staying indoors and keeping the body warm. There was complete remission of the trouble during the summer months and each succeeding winter it had been growing progressively worse. Cyanosis appeared the second year following the onset of the trouble and the hands became stiff, extremely susceptible to cold, and small ulcers developed on the malleolar surfaces of the ankles; also trophic changes were present on the skin of the ear lobes and on the tips of the fingers. The subjective complaint was aching in the calves of the legs, and in the arms, not related to exercise but to the attacks of cyanosis. Paroxysms of change of color could be induced by exposure to cold, drinking cold water, eating cold food, picking up cold objects, or excessive nervousness. On examination the woman was found to be thin, of asthenic type, and with some appearance of scleroderma of the face, although the skin was not definitely sclerosed. In the hands the skin was tight, firm, difficult to pick up, and gradually shaded into normal at the forearms. There was approximately 30 per cent limitation of motion of the fingers. There were minor, punched-out areas in the tips of the fingers. The hands were pale, cyanotic, and extremely cold at ordinary room temperature. The arteries were patent. There was cyanosis of both feet and a mild degree of sclerosis of the skin to the knees. The vessels were open. The diagnosis was that of vasospastic disturbance of the hands and feet, Raynaud's disease, scleroderma probably of the secondary or vasomotor type, and adenomatous goiter without hyperthyroidism. The patient was given medical advice and returned home for the summer. She returned, October 11, 1927, so that operation on the sympathetics for the relief of the condition of the lower extremities might be considered. There had been no change in the condition or in the subjective symptoms. The vasomotor index was 3.7 in the right and 5.4 in the left foot, indicating a high grade of vasomotor spasm in the feet. Bilateral lumbar ganglionectomy and ramisectomy was done, October 17, 1927. It was noted that after operation the texture of the skin of the feet became much softer and the color was normal, the surface temperature on palpation was increased, and the feet had a fairly normal appearance (Table I). Sweating was absent, and the small ulcerations were completely healed within a period of 3 weeks. Following operation she complained of a dull pain radiating from the hips to the feet, with tenderness along the course of the sciatic nerve. This gradually disappeared 14 days after operation. The patient complained of some burning sensations in the feet. She was dismissed, November 3, 1927, and at this time was in excellent condition except for slight soreness in both hips posteriorly and along the course of the sciatic nerve. There was some hyperæsthesia of the skin along the outer aspect of the thighs. The patient returned June 8, 1928, for re-examination. At this time the feet were warm and excessively dry. There had been entire absence of color changes during the winter months, except on one occasion when the feet became cyanotic for a period of 20 minutes. The skin of the feet was definitely softer. The aching in the legs had disappeared. The only abnormal symptom was that when the feet became excessively warm, burning was noted without change in color. She also stated that the dryness of the feet caused some discomfort. The vessels of the feet were pulsating normally. There was no change in the sclerodermal condition of the hands, which had progressed to the point of definite disability, deformity, and trophic disturbance.

Case 5. The full history of this patient is described in the group undergoing cervical and dorsal ganglionectomy. The operative results indicated complete relief of the symptoms in her hand, and as the condition in the feet had become severe enough to produce symptoms, the patient was rather insistent that operation be carried out at this time. Her complaint concerning the feet was exactly similar to that concerning the hands. There were marked grades of cyanosis on exposure to cold, mild pain, numbness and tingling, followed by periods of recovery in which the recovery was excessive; that is, there was burning, redness, and sweating. The vasomotor index was extremely high, indicating a marked degree of spasm of the surface vessels. Operation, carried out October 23, 1928, consisted in bilateral lumbar ganglionectomy and removal of the sympathetic trunk. The postoperative convalescence was uneventful. Tables I and II show the surface temperature and the results of calorimetric studies.

There were no untoward results of the operation; no paræsthesias or nerve tenderness could be elicited. This patient was then discharged with complete relief of Raynaud's disease of the four extremities (Fig. 16, frontispiece).

CASE 6. A woman stenographer, aged 31, entered The Mayo Clinic April 26, 1928. She gave a history of having had cold feet for many years and that the condition gradually had become worse during the last 5 years without the appearance of noticeable color changes. For the last 2 years she had noticed that the feet became markedly cyanotic during periods of cold weather; the distribution of the cyanosis was symmetric and involved all the toes and the distal parts of the feet. With increase in the local temperature, the feet would become red, hot, and burning. There was an increasing tendency for the attacks of cyanosis to become more prolonged and for recovery to be less complete. Pallor had never been observed. The patient had congenital club feet. In 1922 both fifth toes had been amputated because of the presence of hammer-toe. For the last 4 months, she had noticed small blisters on the distal portions of the toes which had healed and broken down from time to time. The subjective symptoms consisted of tingling, dull aching in the feet during the periods of cold weather, and relief in the summer months. There was cyanosis of the hands with chilling. Thyroidectomy was done on her first visit, because of multiple adenomata. It was felt best to have this done before operation on the sympathetics was carried out. Recovery from the thyroidectomy was uneventful, and no obvious change was noted in the condition of the extremities. The patient returned, August 28, 1928, and bilateral lumbar ganglionectomy was performed, October 2, 1928. The postoperative results were rather striking. The usual vasodilation was present and sweating disappeared distally from a line approximately 4 inches below the knee (Table I). The vessels of the feet became excessively enlarged and pulsations were exaggerated, approximating those observed in the normal radial arteries. All color changes and all subjective symptoms disappeared from the feet. The patient was dismissed 3 weeks after operation. Exposure to cold weather, without color changes or other symptoms, indicated a satisfactory result. It is probable that the condition of the hands will show the usual slow progression and that an operation on the dorsal ganglia eventually may become necessary. Table II and Figure 17 show the summarized data on the surface temperature and rate of heat elimination in the preceding cases.

TABLE II.—SUMMARY OF THE CHANGES IN SURFACE TEMPERATURES AND IN THE RATE OF HEAT ELIMINATION IN THE FEET FOLLOWING LUMBAR GANGLIONECTOMY.

Case	Maximal increase in skin temperatures, Degrees Centigrade			Heat elimination in small calories each minute for each square inch of surface area	
	Lowest before operation	Highest after operation	Increase	Before	After
1	31.2	35.5	4.3	0.51	0.85
2	22.1	36.6	14.5	0.44	1.32
3	23.9	36.1	12.2	0.94	1.04
4	22.2	33.2	11.0	1.21	0.69
5	19.9	32.7	12.8	0.23	1.17
6	15.0	33.2	18.2	0.39	1.03
Average values			12.1	0.62	1.01

DORSAL GANGLIONECTOMY FOR RAYNAUD'S DISEASE AFFECTING THE HANDS

CASE 5. A woman, aged 25 years, 3 years before admission to the clinic suffered from blanching of the right index finger during the early winter months. This was relieved in the summer. The following winter the condition became gradually worse, both hands were involved, with cyanosis to the wrists, associated with numbness and dull aching pain. During the year before she was seen by us, the disturbance had occurred during warm weather, small, dry ulcers developed in different finger tips, and a similar condition developed in the feet. The patient was of the thin, asthenic type; the general examination was otherwise negative. On a summer day the hands were swollen, cyanotic, and full flexion of them was impossible. There was a small, dry ulcer on the end of the right index finger, with an area of permanent cyanosis involving the distal phalanx. The vessels of the hands and feet were patent although the pulsations seemed reduced in magnitude. July 31, 1928, the first and second thoracic sympathetic ganglia and trunk were removed on the right side. The following day, the right hand was warm and dry. During the following week, marked increasing dryness of the skin was noticed by the patient over the entire right arm, axilla, and right side of the face. She noted the same changes on the right anterior surface of the chest to the level of the sixth interspace and on the right posterior surface of the chest to the level of the fifth dorsal vertebra. The pilomotor reaction was not elicited over the entire right arm. The morning after the operation the right pupil was contracted, enophthalmos was present, and the right cheek was slightly warmer than the left. A complete Horner's syndrome was not present, as dilation of the pupil could be elicited with cocaine. The preoperative aching distress in the right hand and arm entirely disappeared. Special studies on the temperature changes were carried on 3 weeks after operation (Table III and Fig. 18).

September 11, 1928, the first and second dorsal and inferior cervical ganglia were removed on the left side. Forty-eight hours after operation the patient complained bitterly of pain in the back from the occiput down to the level of the scapulæ. The pain disappeared in a few days. Definite hyperæsthesia

TABLE III.—SURFACE TEMPERATURE OF HANDS BEFORE AND AFTER RIGHT AND LEFT GANGLIONECTOMY (CASE 5)

Date	Outdoor temperature, °C	Room temperature, °C	Surface temperature, Degrees Centigrade								Comment
			Right hand				Left hand				
			Index finger	Third finger	Dorsum	Palm	Index finger	Third finger	Dorsum	Palm	
7-20-28	26.1	24.0	22.7	23.2	24.1		24.1	24.3	25.2		Hands cold, swollen, and markedly cyanotic.
7-24-28	21.1	21.5	24.2	24.9	25.8		25.5	25.3	27.0		Marked cyanosis.
7-28-28	22.2	21.5	24.0	25.0	24.0		25.9	27.7	29.0		Marked cyanosis.
7-31-28											Right dorsal ganglionectomy.
8-4-28	34.4	26.0	32.3	33.1	33.8		31.7	32.6	34.5		
8-7-28	36.7	27.0	33.1	31.4	34.7		32.6	30.9	35.0		
8-20-28	26.7	22.5	32.5	34.7	32.3		26.2	25.9	28.9		Right hand warm, dry, and of normal color; left hand cyanotic and cold.
9-3-28	20.0	23.5	34.9	34.4	32.0		33.7	31.8	29.3		Both hands warm; right dry.
9-5-28	20.0	22.0				33.6				24.4	
9-11-28											Left dorsal ganglionectomy.
9-25-28	8.9	23.0	32.9	34.7		34.9	34.4	34.4	34.7		
10-11-28	13.3	22.5	32.8	31.0	31.0	31.2	32.6	32.3	30.9	32.5	Both hands of normal color and dry.
10-13-28	14.4	22.5	32.0	32.2	31.7	32.4	31.8	32.3	30.7	31.5	Weather rainy and cold, feet cyanotic.
10-15-28	20.0	20.3	33.8	34.0	33.1	35.2	32.9	33.1	31.9	35.1	Hands dry and warm.
10-17-28	10.0	22.0	34.9	34.9	33.9	36.1	34.1	34.2	33.1	35.3	
10-18-28	8.9	21.0	33.0	32.6	31.8	33.6	32.9	32.6	32.1	33.5	Hands normal.
11-12-28	2.2	19.9	28.1	29.5	29.4	30.0	27.5	28.5	30.0	30.3	Body exposed in cold room, no color change in hands.

was present in this area. The left pupil was contracted to a greater degree than the right pupil. Enophthalmos and narrowing of the palpebral fissure were more marked than in the right eye. The left hand was hot and dry, and the skin was shiny. There was no significant variation in the rate of the heart. Convalescence was uneventful. Fifteen days after the last operation, the examination of the eyes by Dr. Wagener showed that the right pupil measured 3 millimeters and the left, 2 millimeters. After cocainization, the right measured 4 to 5 millimeters and the left, 2 millimeters. The left palpebral fissure was narrower than the right. It was evident that Horner's syndrome was present in the left eye but had almost disappeared from the right. The examination of the patient at this time showed complete absence of sweating, under ordinary room temperature, of both arms, face, and anterior and posterior surfaces of the chest to the level noted. Some moisture was felt subjectively in the left axilla; with pilocarpine, sweating could be induced over the entire body. The pilomotor reflex was absent over both arms but was present over the shoulders. The rate of the heart was normal and responded with normal acceleration to usual exercise. The patient complained of soreness in the operative area, and slight tenderness was elicited by palpation of the brachial arteries. The hands remained warm and dry. The ulceration had entirely healed. No color changes could be induced by sudden changes in the room temperature. The pulses felt normal and the excursion of the pulse, as determined by palpation, was wide. The surface temperatures of the hands remained high and the lowest value obtained in a cold room was 27 degrees C. In the tip of the right index finger there was a lesser rise in temperature than in its opposite. With chilling, there was a slight degree of cyanosis in this area due, we believe, to thrombosis of the distal portion of the digital artery from secondary infection from the ulcer. The rate of heat elimination for the entire right hand increased from 22 to 80 calories for each minute (Table IV). Lumbar ganglionectomy was done October 23, 1928, and the effects are noted under the heading dealing with this operation. Complete calorimetric and thermometric determinations were carried out on all extremities November 10, 1928 (Table IV). There was no change in the surface temperature or in the rates of heat elimination after this interval of time. On cold days color changes were entirely absent and both hands and feet remained warm and dry. Examination of the eyes at this time showed almost complete dilation of the right pupil and partial dilation of the left, indicating that Horner's syndrome was no longer complete in the left eye. The neurologic examination was negative except for an area of anæsthesia about the operative scar (Fig. 19, frontispiece).

CASE 2. The history of this patient is given in the group of those who had lumbar ganglionectomy. There was complete recovery in the feet after operation and they were observed repeatedly over a period of 3 years. During this time, the condition of the hands had become progressively worse. A condition of chronic cyanosis had developed and recovery from increased temperatures was incomplete and evanescent. The hands remained swollen, sweating continuously, and these symptoms were accompanied by continuous dull aching distress. During the periods of colder weather, it was impossible for the patient to go outdoors. Minute areas of dry gangrene developed in the ends of the fingers. In an attempt to obtain relief, bilateral removal of the middle cervical ganglion and what was thought to be the stellate ganglion together with perivascular neurectomy of the right brachial artery was done. The effects of this operation on the circulation of the hand were equivocal and transitory. A bilateral, incomplete Horner's syndrome was present and has persisted. The patient states that the amount of saliva has increased. Palpitation of the heart was noted after operation. The electrocardiographic report was of a rate of 87 and sinus rhythm. Cyanosis of the hands reappeared with exposure to cold. The disturbance in the hands continued to grow worse: they were continually cyanosed and swollen, and there was a continuous aching pain radiating to the elbows; small dry ulcers appeared from time to time on the finger tips. The contrast between the condition of the hands and that of the feet was most striking, but it was extremely disconcerting to the patient. An irritable heart syndrome had developed, with disagreeable subjective sensations. November 9, 1928, bilateral dorsal ganglionectomy was done. Forty-eight hours after operation the patient complained bitterly of pain in the back and shoulders, largely in the interscapular area. The hands were warm, dry, and pink. The swelling had become perceptibly reduced. Convalescence was slow but satisfactory. Fifteen days after operation, temperature studies and calorimetric determinations were carried out and the results are shown in Tables IV and V. Twenty-five days after operation, she still complained of soreness and pain in the area in the back, and of tenderness in the shoulders and along the brachial artery. Hyperæsthesia of the skin was present in both arms to the shoulders. The condition of the hands has remained most satisfactory and has paralleled in improvement that observed in the feet. The temperature of the left hand was higher by one to two degrees Centigrade than that of the right. Sweating under room temperatures, as tested with Cobalt blue test papers, was absent over the anterior part of the chest and forehead and over both arms to about the fifth interspace. The axillæ were moist, while the skin showed no abnormal dryness to the middle of the forearms. The pilomotor reactions were visible to an irregular line 5 to 7.5 centimeters distal to the elbows. There was some residual swelling and redness in the hands, which was aggravated by allowing them to hang down. The skin was loose, as seen in the skin in some cases of nephritis after œdema has disappeared. The results in this case probably were more satisfactory than those obtained in Case 5. However, the better results may have been apparent only because of the aggravated condition of the hands before operation. The cardiac response to exercise was that of a normal acceleration of rate, quite parallel with the pre-operative response, although she states that palpitation during the night is troublesome. An irritable heart syndrome is believed to be present.

UNSUCCESSFUL CERVICAL SYMPATHETIC GANGLIONECTOMY FOR RAYNAUD'S DISEASE OF THE HANDS

CASE 7. An Italian woman aged 46 years, a housewife, came to the clinic because of indefinite stomach trouble and circulatory disturbances in the hands. She had noted for the last 15 years that the fingers would get very blue when they were exposed to cold or following the application of cold water. The discoloration extended to the metacarpophalangeal joints. The color alternated from pallor to cyanosis followed by rubor, or from pallor to rubor. General examination was essentially negative. On examination the hands were found to be blue; there was pallor of the finger tips, trophic disturbance of the nails and tips of the fingers, and firm, sclerodermalike tissue in the fingers. Radial and ulnar pulsations were normal. The feet were cold and the vessels, open. There was no history of symptoms in the feet at this time. The diagnosis was vasospastic disturbances, Raynaud's disease, secondary sclerodermal changes of the hands, and trophic ulcers of the fingers. April 22, 1925, the left superior and middle and inferior sympathetic ganglia, with rami and trunks, were removed. The patient's convalescence was uneventful. In the left hand there was a short period of increased surface temperature which had entirely disappeared when she left the hospital. By thermometric and calorimetric studies increased temperature of the left and right hands could not be demonstrated. A Horner's syndrome was present on

TABLE IV.—CHANGES IN SURFACE TEMPERATURE AND THE RATE OF HEAT ELIMINATION ON THE HANDS FOLLOWING BILATERAL DORSAL GANGLIONECTOMY*.

	Case 2	Case 5
Maximal increase in skin temperature, degrees Centigrade		
Before	21.0	23.3
After	32.7	32.8
Increase	11.7	9.5
Heat elimination in small calories, each minute		
Before	10	22
After	34	80

*Postoperative readings taken four and ten weeks after operation.

TABLE V.—SURFACE TEMPERATURE OF HANDS BEFORE AND AFTER RIGHT AND LEFT DORSAL GANGLIONECTOMY (CASE 2)

Date	Temperature, Degrees Centigrade								Comment
	Out-door	Room	Right hand			Left hand			
			Second finger	Third finger	Palm	Second finger	Third finger	Palm	
6- 9-26		24.4	23.6						
10- 8-26		22.0	21.2			20.7			
10-29-28		22.0	20.1	20.6	23.8	20.7	19.8	23.5	Hands cyanotic and cold.
11- 7-28		24.0	25.8	26.2	26.8	25.0	24.6	28.7	Swollen.
11- 8-28		23.0	23.4	22.5	24.6	24.0	24.2	24.9	
11- 9-28									Right and left dorsal ganglionectomy.
12- 5-28	20.0	23.5	32.1	32.5	33.5	32.5	33.3	32.5	Both hands warm, dry, and of normal color.
12- 6-28	28.0	20.0	30.0	28.5	32.0	29.5	31.0	32.5	
	32.0	24.0	31.4	31.9	31.4	30.5	32.5	30.4	
12- 7-28	20.0	23.0	29.7	28.9	32.9	31.1	31.7	31.1	Right hand slightly cooler than left after exposure to cold air.

the left side. The skin of the left cheek was somewhat warmer than that of the right. It was observed that following exposure to cold, the vasomotor reactions were much more active in the right than in the left hand. Subsequent letters from the patient have indicated that the condition has remained practically the same. Permanent changes in the blood supply of the hand or abolition of the vasoconstrictor attacks were not accomplished.

CASE 8. A young Russian girl, aged 23 years, a bookkeeper, entered the clinic, July 12, 1926. In 1919 the patient had had a mild attack of influenza; following this she had noted coldness, numbness, and bluish discoloration in both hands from the second phalangeal joints. The only excitant had been cold. The condition gradually had become worse. For the 2 years preceding admission to the clinic, during winter months, pain limited to the second and third fingers had developed with exposure to cold. Three years before she was seen by us blisters had developed on the tips of the four fingers. These all had broken down and had healed. The condition had progressed to the time of admission so as to constitute complete disability. A similar condition, but milder, was present in the feet. On examination the arteries of the hand were found to be open. Marked cyanosis was present under usual room temperatures; when exposed to increased environmental heat, the hands became hot, red, and moist, and there was burning pain. The diagnosis was vasospastic neurosis, or Raynaud's disease involving the hands and feet. August 3, 1926, right cervical ramisection, according to the technique of Royle, was carried out. The brachial roots were exposed and all the rami divided. Twenty-four hours after operation the patient was in good condition. Both hands were warm and no perceptible difference was noted between the two. The following day, the right hand was a trifle more pale than the left, but there was no difference in surface temperature. The pupils were equal; Horner's syndrome was not present. Convalescence was uneventful. Studies carried out 2 weeks later showed no demonstrable difference in the surface temperature or in the rate of heat elimination in the two hands. Exposure to the cold air produced color changes, possibly not of so severe a grade as before operation. This patient was seen in 1928, in Florida, and it was evident that no improvement had been obtained by this operation.

SUMMARY

In five cases of vasomotor neurosis of the spastic type, with symptoms (Raynaud's disease), there was marked and maintained vasodilation in the feet for periods as long as 3 years following operation. Vasomotor activity, as measured by the surface temperature, was absent or markedly diminished, with complete relief from the signs and symptoms of this disease.

Cervical sympathetic ganglionectomy by the anterior approach, carried out in two cases of Raynaud's disease of the hands, was unsuccessful in producing vasodilation or in ameliorating the signs or symptoms.

Intrathoracic sympathetic ganglionectomy by the dorsal approach was successful in two cases of Raynaud's disease affecting the hands, producing dilating effects on the arteries of the hands comparable to that observed in the feet following the lumbar operation.

The striking, maintained, and unequivocal therapeutic effects of lumbar and dorsal

sympathetic ganglionectomy in Raynaud's disease seem to warrant the belief that surgical control in this disease is an accomplished fact.

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DEVELOPMENTAL ABNORMALITIES AT THE LUMBOSACRAL JUNCTURE CAUSING PAIN AND DISABILITY

A Report of One Hundred and Forty-Seven Patients Treated by the Spine Fusion Operation

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AT the New York Orthopædic Dispensary and Hospital in the period from October, 1914 to January, 1927, 147 patients had a lumbosacral fusion operation for the relief of low back pain and disability which was thought to be due to some purely mechanical defect at the lumbosacral juncture, the result of an anatomical variation. The time elapsed since these operations has been from 2 to 13 years, an average of 4 years, which is sufficient to allow a fair estimate of the results, and a report is therefore being made of all of them. Three of the patients had to have a second operation before January 1, 1927, because of a pseudarthrosis, and so this report covers a total of 150 operations.

The lumbosacral juncture is believed to be the part of the spine most vulnerable to mechanical stress and strain for two main reasons: first, because it is the place where the weight and movements of the trunk are transmitted from the mobile spine to the fixed base, the sacrum; and second, because it has become clear that in this area there are very frequent abnormalities of bone and joint structure, any one of which may form a lumbosacral mechanism less fitted than the so-called normal to perform its required functions. This does not mean that all individuals with some abnormality of the lumbosacral area have symptoms from it, but it does mean that if an individual has symptoms referable to the low back and is found to have in the lumbosacral region an anatomical variation, the latter may well be held responsible for the symptoms until proved innocent. The question of low back symptoms arising from a sacro-iliac joint cannot be considered in this report except to say that in all these patients no evidence of sacro-iliac pathology was recognized.

The 147 patients are divided into five groups according to the anatomical variations found, and each group will be analyzed separately. They are as follows:

I. Patients who had one or more of these conditions: (a) an abnormally acute angle between the fifth lumbar and first sacral bodies; (b) irregularly placed or asymmetrical lateral articulations of the fifth lumbar and first sacral vertebræ; (c) impinging spinous processes of the lower lumbar and sacral vertebræ; (d) defects in closure of the posterior arch of the first sacral vertebra; (e) incomplete bony union between the first and second sacral segments.

II. Patients who showed changes in the last presacral vertebra such that it approached in type a sacral vertebra but without complete bony union to the sacrum, and evidenced also by an enlarged transverse process articulating with the lateral mass of the sacrum on one or both sides. This condition is called incomplete sacralization of the fifth lumbar vertebra.

III. Patients who had a spondylolisthesis or a slipping forward of the body of the fifth lumbar on the sacrum, because of failure of union of the arch of the fifth to its body.

IV. Patients who had been included in Group I but who were found at operation to have ununited or badly united fractures of a lamina or articular process.

V. Patients who had a posterior displacement of the fifth lumbar vertebra on the first sacral.

Before proceeding to an analysis of each group there are certain things to be said about the entire series.

The first operation was done October 13, 1914, on a girl aged 13 who had spondylolisthesis.

There were 75 males and 72 females, and the ages of the patients at time of operation varied from 10 to 54 years according to the following table:

Years	Males	Females	Total	Percentage
1 to 10	0	1	1	0.7
11 to 20	7	13	20	13.6
21 to 30	25	29	54	36.7
31 to 40	24	20	44	29.9
41 to 50	18	8	26	17.7
51 to 60	1	1	2	1.4
	75	72	147	100.0

It will be seen that the largest group, 36.7 per cent, was between 21 and 30 years old and that 66.6 per cent of the patients were between 21 and 40 at the time of the operation. The average age of the series was 30.7 years when the operation was done, but this does not necessarily represent the age at which the symptoms began. It may be said, however, that the symptoms rarely begin until ossification is complete, at which time the capacity for accommodation to mechanical strain is lost to a large degree, and that they increase with advancing age.

In each case the diagnosis was arrived at after a study of the history, physical examination, and X-rays, the latter probably being the most important factor. Our understanding of the mechanism of the lumbosacral juncture and its anatomical variations has been much enhanced by the very careful work of von Lackum[1] based on a large number of anatomical dissections. The knowledge thus gained has been of great value clinically and especially so as steadily improved X-ray technique has made it possible actually to visualize the lumbosacral juncture. It is now considered necessary to have stereoscopic anteroposterior views of the fifth lumbar and sacrum, clear lateral views with the patient lying and standing, and an anteroposterior view taken from below at an angle of 45 degrees. This latter brings out more clearly the sacroiliac joints and also the fifth lumbar and sacral relationships.

There was no operative death in this series of 150 operations and no instance of postoperative shock. One patient has died but his death was not associated with the operation, it having been due to a carcinoma of the rectum and occurring 8 months later.

The operation in each instance was done according to the Hibbs technique, with very great care in doing a subperiosteal dissection, in removing all the ligamenta flava, and in curetting the lateral articulations. No bone-graft or osteo-periosteal graft was used because the large laminæ of the lumbar vertebræ and the wide surface of the sacrum afforded plenty of bone for the necessary fusion. Although the exposure is sometimes difficult on account of the depth of the wound in some individuals, there is no reason for not obtaining a perfectly satisfactory fusion provided sufficient care and attention to detail are exercised. The operation is now made easier by the use of a table on which the patient may be placed with the thighs flexed at right angles, thereby reducing the lumbar lordosis.

The duration of each operation was as a rule between an hour and an hour and a half. They were done by one of the four attending surgeons.

The postoperative treatment consisted of a period of recumbency in bed for 6 to 8 weeks, during which time a light steel lumbosacral brace was applied. The length of time this brace was worn after the patient was ambulatory varied between 3 months and a year and depended greatly on the type of patient. The tendency has been to shorten the period during which support is used.

It has not seemed worth while to try to draw any conclusion as to the average length of time before the patients returned to their full activities as this period again varied so greatly with each one and depended so much on the individual's economic status and the character of his work. Patients were expected to be able to undertake anything except heavy work by the end of 4 months, and any restriction as to activities was removed by the end of 8 months. The experience of having had an injury to, or an operation on, the spine seems to create in many persons a psychological sense of apprehension and carefulness which it is hard for them to overcome and which the surgeon must treat intelligently if he wishes to shorten their convalescence.

[1] Lackum, H. L. von. Lumbosacral region. J. Am. M. Ass., 1924, lxxxii, 1109.

Eight patients in this series in whom it was suspected that fusion was not complete, because of the persistence of severe symptoms at the end of 7 or 8 months, have had exploratory operations at which a pseudarthrosis was found and repaired. Only three of these second operations are included in the report as the other five have been done since January 1927.[1]

An effort has been made to follow each patient at frequent intervals during the first year, and after that at least once or twice a year for as many years as possible. As will be indicated, a number of persons have been lost for one reason or another before it was possible to be certain of the result, but on the whole the follow-up seems to have been quite satisfactory.

The results of these operations have been classified as follows: (1) patients who have complete relief from their previous symptoms; (2) patients who are improved but still have a few symptoms; (3) patients who are unimproved.

A detailed analysis of each of the five main groups of patients will now be given.

GROUP I

This group consists of the persons who were found to have one or more of the following abnormalities:

1. An acute angle between the fifth lumbar and first sacral vertebræ as determined by lateral X-rays. The mechanical situation at the lumbosacral juncture is not adequately expressed by the measurement of any one single angle. In the first place, an inclination of the articular surface of the first sacral vertebra of more than 42.5 degrees to the horizontal constitutes a mechanical weakness. In the second place, if the center of gravity of the trunk, approximately represented by a vertical line drawn through the center of the body of the third lumbar vertebra, passes anterior to, instead of through, the body of the first sacral, a mechanical weakness is present. In this report a case showing one or both of these mechanical weaknesses is classed as an acute lumbosacral angle. For a complete description of these relationships, reference is again made to the article by von Lackum, from which Figure 1 is reprinted.

2. Irregularly placed and asymmetrical lateral articulations of the fifth lumbar and first sacral.

3. Impinging spinous processes of the lower lumbar and sacral vertebræ.

4. Defects in closure of the posterior arch of the first sacral vertebra.

5. Incomplete bony union between the first and second sacral segments. It is impossible to say in any one instance which of these findings was actually responsible for the symptoms as most of the patients had a combination of two or three of them, and so all of these abnormalities are grouped under one heading. Any one of them alone, however, may be a cause of lumbosacral weakness and pain.

In this group are reported 78 patients and 79 operations, as one person had a pseudarthrosis which required a second fusion. There were 35 males and 43 females.

The ages of the patients varied from 13 to 52 years, the average being 33.4 years. The youngest patient was a girl who had congenitally dislocated hips. These had been unsuccessfully treated by closed reductions and she developed a severe lumbar lordosis with a very acute lumbosacral angle, causing low back pain. She was relieved of the symptoms after the fusion operation. The following table gives the age distribution of this group.

TABLE OF AGES, GROUP I

Years	Males	Females	Total
1 to 10	0	0	0
11 to 20	2	9	11
21 to 30	11	19	30
31 to 40	11	10	21
41 to 50	10	5	15
51 to 60	1	0	1
	35	43	78

Symptomatology. The symptoms complained of varied from simply a weak back causing the patient to tire easily, to very acute pain in the low back with real disability. There was a very frequent history of having had attacks of pain with an intervening period of comfort lasting several years perhaps but becoming more and more frequent or constant as age advanced. The exact location of the pain has

[1] The follow-up on the five operations for pseudarthrosis which are not reported is too short, but at the present time one has been entirely relieved, three are unimproved, and the condition of one is unknown.

been hard to determine from the descriptions in the records and from the patients' memories, a long time after the operation, but it seems clearly to have been referred to the lumbosacral region, frequently to radiate, and to be relieved by rest or often by a tight pelvic corset. The exact character of the radiation pain has also been hard to determine and no definite nerve root distributions can be given. In some patients the pain seems to have radiated into the buttocks or hips, in others into the backs of the thighs, in others into the calves of the legs, and in others along the entire course of the sciatic nerve on one or both sides.

Duration of symptoms. The duration of symptoms before operation varied a good deal. The longest period was 25 years, the shortest was 1 month, and the average 6 years.

History of injury. There was a positive history of injury or strain at the onset of symptoms in 41, or 52.5 per cent, and a negative history in 37, or 47.5 per cent.

Radiation of pain. A history of radiation of pain was obtained in 38, or 48.7 per cent, the radiation being unilateral in 29 and bilateral in 9. There was no radiation in 40, or 51.3 per cent. As said before, nothing definite is concluded as to the actual distribution of the radiated pain.

RESULTS OF OPERATIONS, GROUP I

	Number of operations	Percentage
Class 1. Entirely relieved.....	58	73.4
Class 2. Improved.....	10	12.7
Class 3. Unimproved.....	11	13.9

Of the patients in Class 1, 6 were lost before a year elapsed, but they had no symptoms when last seen. They may or may not still be free of symptoms.

Of the patients in Class 2, 4 were lost before a year had elapsed. The cause of the persistence of symptoms in this class is not determined. None of them is incapacitated and all those who have been followed say that they are very much better than before the operation.

Of the patients in Class 3, only 1 was lost before a year of follow-up. When last seen, at 9 months, he was having a great deal of pain, was thought to have a pseudarthrosis, and was advised to have an exploratory operation.

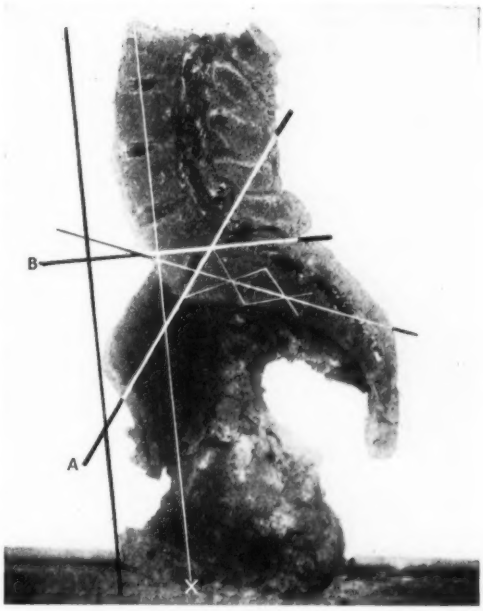

Fig. 1. Method used in determining the mechanical situation at the lumbosacral juncture. The angle formed by *A* and *B* represents the inclination of the articular surface of the first sacral vertebra to the horizontal and should not exceed 42.5 degrees. The line *x* indicates whether or not the center of gravity of the trunk passes in front of the body of the first sacral vertebra.

Three patients had second operations and pseudarthrosis repaired, one of whom is reported in this series and has apparently failed a second time to fuse as she is still unrelieved. At the second operation it was found that there had been no apparent attempt to regenerate bone anywhere in the fused area, and presumably a similar condition existed after the second fusion. Three patients seem to have a definite arthritis of the lumbar spine and this is thought to be responsible for the continuance of their symptoms. Two patients still have symptoms which are suggestive of sacro-iliac pathology and in these an error of diagnosis may have been made. The X-rays in these two seem to show good fusion.[1] Another patient has had a recent second operation at which the fusion was found solid but

[1] Both of these patients have recently been operated on. One man was found to have a pseudarthrosis, which was repaired. One woman was found to have very excellent fusion, but on exploring the sacro-iliac joint it appeared that there was an arthritis present and an arthrodesis of that joint was done.

several exostoses at its upper margin were clearly impinging against the next lumbar vertebra, and it was thought accounted for the pain. She is, however, still unimproved.

GROUP II

In this group are those patients who were found to have the last lumbar, or first presacral, vertebra more or less of a sacral type but without firm bony union to the sacrum, a so-called incomplete sacralization. The most striking instance is that in which the transverse processes are greatly enlarged, either unilaterally or bilaterally, thus forming an articulation with the lateral mass of the sacrum. Such a condition is thought to be very susceptible to strain, and in patients with it a lumbosacral fusion has been done in order to incorporate in the sacrum the vertebra which nature had left partly sacral. This procedure would seem to be more reasonable and is certainly easier to do than the removal of an enlarged transverse process. The latter, if accomplished, has the definite disadvantage of giving more mobility to a vertebra which is not adapted anatomically for motion.

The group comprised 32 patients and 33 operations, as one patient had a second operation for pseudarthrosis.

There were 17 males and 15 females.

The ages varied from 10 to 47 years, the average being 30.6 years. The ages were distributed as follows:

TABLE OF AGES, GROUP II

Years	Males	Females	Total
1 to 10	0	1	1
11 to 20	2	1	3
21 to 30	8	4	12
31 to 40	5	6	11
41 to 50	2	3	5
51 to 60	0	0	0
	17	15	32

The youngest patient was a girl who had been under treatment for several years and was suspected of having tuberculosis of a hip-joint because of pain referred to that region. X-rays of the hip were consistently negative for any evidence of tuberculosis, but they did show an incompletely sacralized fifth lumbar vertebra. It was finally decided that this condition was the cause of her persisting symptoms and a lumbosacral fusion was done and was followed by complete relief. There have since been several somewhat similar experiences.

Symptomatology. The clinical picture varied little if at all in these patients from that described under Group I, except that there was a 12 per cent higher incidence of radiating pain.

Duration of symptoms. The longest period of symptoms before operation was 37 years, the patient being a woman who was operated on when she was 47 and who has been entirely relieved. The shortest period was 1 month, and the average was 2 years and 9 months.

History of injury. A history of injury or strain at onset of symptoms was positive in 18 patients, or 56.2 per cent, and was negative in 14 patients, or 43.8 per cent.

Radiation of pain. Radiation of pain was present in 20 patients, or 60.6 per cent, and was absent in 13 patients, or 39.4 per cent. As said before, no data as to nerve root distribution of pain can be given, but the following facts are of interest regarding the patients who did have radiating pain.

There were 16 patients who had a bilateral incomplete sacralization of the last lumbar vertebra. Ten of these, or 62.5 per cent, gave a positive history of radiating pain. Of these 10, 6 had radiation in both legs and 4 in only one leg.

There were 17 patients who had a unilateral incomplete sacralization. Ten of these, or 58.8 per cent, gave a positive history of radiating pain. Of these 10, 5 referred the radiating pain to the leg on the side of the sacralization and 5 referred it to the opposite leg. Two of the last 5 have not been entirely relieved of their symptoms.

RESULTS OF OPERATIONS, GROUP II

	Number of operations	Percentage
Class 1. Entirely relieved	24	72.7
Class 2. Improved	6	18.2
Class 3. Unimproved	3	9.1

Of the patients in Class 1, 5 were lost before a year of observation but were well when last seen.

Of the patients in Class 2, all have been followed well beyond a year and the reason for the persistence of symptoms is not explained.

None of them has severe pain and several seem to be getting better.

Of the patients in Class 3, 1 was not relieved when last seen, 7 months after operation. One was relieved of painful symptoms but not of a drug addiction acquired before operation. One was re-operated on for a pseudarthrosis, with entire relief, and he is included also in Class 1.

GROUP III

This group consisted of those patients who had a spondylolisthesis with a forward displacement of the fifth lumbar to a distance varying from about one-quarter inch to the full width of the body of the vertebra, the most extreme instance being one in which the body of the fifth lumbar was lying actually in front of, and at practically the same level as, the first sacral. There was found uniformly to be a separation of the laminæ of the fifth lumbar from its pedicles at a point dorsal to the superior articular facets, so that there was no bony anchorage to prevent the body of the fifth lumbar with the superimposed spine from slipping forward. This is believed to be a congenital defect, and it seems obvious that an operation which will produce strong bone fusion between the fourth or third lumbar vertebra and the sacrum is the logical procedure to employ in order to give stability to such a spine.

There are reported in this group 23 patients and 24 operations, one patient having had a pseudarthrosis repaired. There are 15 males and 8 females.

The ages varied from 13 to 51 years, the average being 28.9 years, which is noticeably lower than the age of the other groups. The patients were distributed in these age periods:

TABLE OF AGES, GROUP III

Years	Males	Females	Total
1 to 10	0	0	0
11 to 20	3	2	5
21 to 30	5	4	9
31 to 40	5	1	6
41 to 50	2	0	2
51 to 60	0	1	1
	15	8	23

The youngest patient, a girl aged 13 years, had had symptoms for several years and a kyphos at the lumbosacral region thought at first to be due to tuberculosis of the spine. The oldest patient was a nurse, aged 51 years, who had had no symptoms until the age of 41 years, when she had an attack of severe pain after lifting a patient. This was relieved in a few months and she had no further trouble for 9 years. Then she had a recurrent attack of severe pain, and for a year before the operation her disability and pain were steadily increasing. Both of these patients have had complete relief.

Symptomatology. The clinical picture did not differ in any special respect from that of the other groups except that the physical examination usually revealed the typical severe lumbar lordosis and prominent spinous process of the fifth lumbar and sacrum. The X-ray examination, of course, gave the diagnosis.

Duration of symptoms. The longest period was 20 years, the shortest 1½ months, the average being 1 year and 10 months.

History of injury. There were 11 patients, 47.8 per cent, who gave a positive history of injury or strain before the onset of the symptoms, and 12, or 52.2 per cent, who had no injury. It is very interesting that injury was a factor in a definitely smaller percentage of patients than in any of the other groups.

Radiation of pain. A positive history of radiating pain was given by 15 patients, or 62.5 per cent, and a negative one by 9, or 37.5 per cent. Of the 15 patients who had a history of radiating pain there were 8, or 53.3 per cent, who had it in only one leg, and 7 who referred it to both legs. The region to which the pain was referred varied between the buttocks, the hips, the thighs, and the legs. No exact distribution can be given.

RESULTS OF OPERATIONS, GROUP III

	Number of operations	Percentage
Class 1. Entirely relieved	16	66.9
Class 2. Improved	3	12.5
Class 3. Unimproved	5	20.8

Of the patients in Class 1, all but one have been followed for periods ranging from 1½ to 14 years. That one was free of symptoms when last seen 8 months after operation.

Of the patients in Class 2, all have been followed more than 1½ years. None is complaining of severe pain and they seem to be steadily improving.

Of the patients in Class 3, one woman has been advised to have an exploratory operation as a pseudarthrosis is suspected. Two men have been re-operated on successfully for a pseudarthrosis, one of these second operations being included in this report under Class 1. One woman has been re-operated on at another hospital. One patient, a man aged 42 years at the time of operation, died 8 months after the operation with a diagnosis of carcinoma of the rectum. Whether or not this condition was responsible for his pre-operative symptoms cannot be determined. He gave no history of injury nor of radiating pain before operation, but he did have lumbar muscle spasm and pain on bending the spine, and he was completely disabled. He complained of bowel symptoms for the first time about 3 months after the operation.

The higher incidence of pseudarthrosis in this group is explained by the pathology, which makes the operation a good deal more difficult than usual and necessitates most meticulous care in the dissection and transposition of bone. It is believed that even in these cases a bone graft is unnecessary.

GROUP IV

In this group are included patients who had definite anatomical variations at the lumbosacral region but who were found at the time of operation to have also ununited or badly united fractures of a lamina or articular process. Which condition actually caused the symptoms is not determined.

There are reported in this group 8 operations on 8 patients, 4 males and 4 females.

The ages varied between the youngest, who was 23, and the oldest, who was 50. The average age was 37.6, which is noticeably older than any of the other groups. The following table shows the age distribution.

TABLE OF AGES, GROUP IV

Years	Males	Females	Total
1 to 10	0	0	0
11 to 20	0	0	0
21 to 30	0	1	1
31 to 40	2	3	5
41 to 50	2	0	2
51 to 60	0	0	0
	4	4	8

Symptomatology. The clinical picture was essentially similar to that of the other groups except, if anything, the symptoms were more severe. It is interesting to note that the roentgenograms did not show any fractures, and it is believed that the presence of many fractures of the posterior elements of the spine can be determined only by exploratory operation.

Duration of symptoms. The longest period of symptoms was 14 years, the shortest period was 6 months, and the average period was 5 years 11 months.

History of injury. An injury had been associated with the onset of symptoms in all of the patients.

Radiation of pain. A history of radiating pain was positive in 5, or 62.5 per cent, and was negative in 3, or 37.5 per cent. Of the 5 patients with radiating pain, 2 referred it to both legs and 3 to one leg.

RESULTS OF OPERATIONS, GROUP IV

	Number of operations	Percentage
Class 1. Entirely relieved	6	75.0
Class 2. Improved	2	25.0
Class 3. Unimproved	0	0.0

Of the patients in Class 1, all have been followed for periods of 1½ to 7 years, except one man who was at work and free of symptoms when last seen 7 months after operation.

One patient in Class 2 was lost 9 months after operation, but he had only a slight amount of pain and seemed to be steadily improving. The other has had several temporary attacks of severe pain in the back but is very much better than before the fusion and is able to carry on a very active life.

GROUP V

In this group were patients in whom a diagnosis was made of a posterior displacement of the fifth lumbar on the first sacral. This condition is very definite and occurs when the lateral articulations between the fifth lumbar and the sacrum are quite long and of the anteroposterior type, as in the thoracic region, thus allowing an unusual degree of anteroposterior mobility between the fifth lumbar and sacrum. The displacement is not necessarily permanent but seems to represent a subluxation of the lateral articulations with

ANALYSIS OF ONE HUNDRED FORTY-SEVEN CASES

Groups	No. of patients	No. of operations	Average age in years	Average duration of symptoms yrs.-mos.	History of injury Per cent	Radiation of pain Per cent	Pseudarthrosis Per cent	Average length follow-up yrs.-mos.	Entire relief Per cent	Improved Per cent	Unimproved Per cent
I.—Acute lumbosacral angle	78	79	33.4	6	52.5	48.7	6.3	3-9	73.4	12.7	13.9
II.—Sacralization 5th lumbar	32	33	30.6	2-9	56.2	60.6	3.0	3-7	72.7	18.2	9.1
III.—Spondylolisthesis	23	24	28.9	1-10	47.8	62.5	8.3	4-2	66.7	12.5	20.8
IV.—Fractures of laminæ	8	8	37.6	5-11	100	62.5	0	4-6	75	25	0
V.—Posterior displacement 5th lumbar	6	6	33.0	4-11	83.3	50.0	0	4-6	100	0	0
Totals	147	150	30.7	4-3	68	54	5-3	4-1	73.3	14	12.7

the possibility of a reduction taking place at any time. In one patient this seemed to occur during the operation, when there was found to be no motion between the fifth lumbar vertebra and first sacral until, while the ligaments were being curetted, something snapped and then there was the usual degree of motion present. The pre-operative lateral roentgenograms of this patient were interpreted as showing a posterior displacement, but the post-operative lateral X-rays did not. There are reported in this group 6 patients and 6 operations, and there were 4 males and 2 females.

The ages of the patients varied from 17 years to 47 years, the average age being 33.

TABLE OF AGES, GROUP V

Years	Males	Females	Total
1 to 10	0	0	0
11 to 20	0	1	1
21 to 30	0	1	1
31 to 40	2	0	2
41 to 50	2	0	2
	4	2	6

Symptomatology. No unusual clinical findings were noted as diagnostic or characteristic, but the X-rays revealed the pathology.

Duration of symptoms. The longest period of symptoms was 20 years, the shortest period was 6 months, and the average period was 4 years 11 months.

History of injury. A history of injury or strain associated with the onset of symptoms was given by 5 patients, 83.3 per cent, but was negative in 1.

Radiation of pain. Radiating pain was present in 3, or 50 per cent, 2 patients referring it to one leg, and 1 patient referring the pain to both legs. Three had no radiating pain.

RESULTS OF OPERATION, GROUP V

	Number of operations	Percentage
Class 1. Entirely relieved	6	100.0
Class 2. Improved	0	0.0
Class 3. Unimproved	0	0.0

One patient was lost at the end of 6 months but was free of symptoms at that time. The others have been followed from 2 to 8 years.

A study of the accompanying table will show the main facts in the analysis of these 147 patients and will reveal the interesting relationships between the separate groups.

SUMMARY

1. One hundred and fifty lumbosacral fusion operations are reported which were done on 147 patients who had low back symptoms which were thought to be due to some purely mechanical defect of the lumbosacral juncture.

2. The operations were all done before January 1, 1927.

3. The first operation was done October 13, 1914.

4. There were 75 males and 72 females in the series.

5. The age at time of operation varied between 10 and 52, the average being 30.7 years; 36.7 per cent of the patients were between the ages of 21 and 30, and 29.9 per cent were between 31 and 40.

6. There was no operative death in the series.

7. Very strong bony fusion of the fifth lumbar to the sacrum is accomplished by the operation.

8. There were 8, or 5.3 per cent, unsuccessful operations, due to a failure of fusion or pseudarthrosis, and these have been re-operated on.

9. The average history of symptoms before operation covered a period of 4 years 3 months.

10. There was radiation of pain into some part of the leg on one or both sides as a preoperative symptom in 81, or 54.0 per cent, of the patients.

11. The results of the entire series of 150 operations are as follows: 110 patients, 73.3 per cent, are entirely relieved; 21 patients, 14.0 per cent, are improved; 19 patients, 12.7 per cent, are unimproved.

12. Some anatomical or mechanical variation of the lumbosacral region is thought to be the underlying cause of the symptoms which are present in many patients who are suffering with low back pain.

In such patients a lumbosacral fusion is considered to be the method of treatment best calculated to give permanent relief, and to be fully justified by the results obtained in this series.

THE BLOOD SUPPLY OF THE THYROID GLAND WITH SPECIAL REFERENCE TO THE VASCULAR SYSTEM OF THE CRETIN GOITER

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ONE of the important phases of the goiter problem in Switzerland is that presented by endemic cretinism. In the Canton of Berne, alone, five institutions with approximately 700 cretin inmates, are devoted to the care of these unfortunate individuals. The interest and considerable study accorded this problem by the Surgical Clinic at Berne is, therefore, at once understandable.

Endemic cretinism occurs only where goiter is endemic. In only a few of the numerous regions where goiter is prevalent, however, does endemic cretinism exist. In mountainous areas where the goiter endemic is especially intense, endemic cretinism is most likely to make its appearance. Professor de Quervain (28) informs me that, among others, five such endemic cretin districts are especially well known, viz.: (1) Cantons Aargau, Fribourg and Wallis in the Swiss Alps; (2) mountainous districts in the Austrian Alps; (3) sections of the Himalaya Mountains; (4) mountainous areas in South America; (5) sections of the American Rocky Mountains.

In an institution devoted to the care of cretins, every gradation of the disease may be seen; variations from idiotic individuals with a status inferior to that of an animal, to those who manifest only slight abnormalities, may be observed. In the severe form of the disease, idiocy, deaf-mutism, retardation of skeletal growth, and myxœdematous changes in the skin are generally present. In such instances, an atrophy of the thyroid gland early in life has usually occurred. In the lighter forms of endemic cretinism, and especially in those instances in which the retardation of skeletal growth is not so marked, such individuals, as Professor de Quervain (30) has pointed out, frequently are cretins with goiter (Fig. 15). Marked mental retardation with speech disturbances or deaf-mutism, however, are also common in such cretins. It is to be presumed that in cretins with goiter, in whom the disease makes its appearance later than in the usually more severe groups of cretins without goiter, the thyroid function for at least the first few years of life was quite sufficient.

Not infrequently, even individuals with the most intense manifestations of the disease fail to exhibit the myxœdematous changes in the skin seen in patients suffering from myxœdema. The uniformly marked reduction of the basal metabolism observed in sporadic cretins or patients with myxœdema, Professor de Quervain and Pedotti (32) did not find in corresponding degree in endemic cretins. They found average values of minus 8 to 11 per cent in cretins with and without goiter.

Undoubtedly, however, the most striking feature of endemic cretinism is hypothyroidism. When endemic cretinism manifests itself in many more gradations than the more uniform picture of myxœdema, it should be remembered, as both Professors de Quervain (30) and Wegelin (40) have pointed out, that the function of the thyroid in the endemic cretin during different periods of development may not always be the same. The appearance of preponderant disturbances in one or other system of organs, e.g., retardation of skeletal growth, in endemic cretinism depends in large measure on the time of the manifestation of the thyroid inadequacy, in relation to the time period in which the growth and development of various structures obtains.

THE THYROID OF ENDEMIC CRETINS

Wydler performed biopsy of the thyroid tissue in a few patients with severe cretinism, at the Surgical Clinic of Berne, in whom no thyroid was to be felt overlying the trachea. Invariably, atrophic tissue scarcely recognizable microscopically as thyroid gland, was found. Microscopically, degenerative changes of high degree were constantly in evidence.

The thyroid of the cretin with goiter is almost uniformly an adenomatous one. Rarely, is a diffuse goiter present in such an individual. Occasionally, also, the thyroid may partake of a colloid nature. The formation of nodules in the cretin goiter apparently occurs early. In the cretin goiter of a girl of 7 years, studied in this series, the adenomatous character of the removed goitrous tissue was already quite obvious (Fig. 1). Wydler (43) has compared a series of non-cretin goiters removed at the surgical clinic at Berne with another from individuals with endemic cretinism. The incidence of degenerative changes in the cretin goiter, he found much greater than for the non-cretin goiter. Especially are degenerative changes more frequent in the extra-adenomatous tissue of the cretin goiter than in that of the non-cretin. In the latter, the degenerative changes are confined largely to the areas about the adenomata, while the remainder of the extra-adenomatous tissue may appear fairly normal. In the cretin goiter, on the contrary, the non-adenomatous tissue may be quite uniformly involved in an atrophic process in which all types of nuclear degenerative changes may be seen. That the cretin goiter has no pathognomonic-histological picture must, however, be frankly admitted. The presence of regenerative areas within the adenomata of cretin goiters is not unusual.

It should be pointed out here that Emilie Woelz observed degenerative changes (fibrosis, calcification, and cyst formation) present more frequently in goiters removed at Basle, during Professor de Quervain's activity there, than in goiters removed at the Surgical Clinic at Berne. Basle lies rather toward the periphery of the goiter endemic and is relatively free from endemic cretinism. This greater incidence of degenerative changes in the adenomata of the non-cretin district at Basle, probably finds its explanation, as Woelz suggests, in the fact that colloid adenomatous nodules are more prone to exhibit degenerative phenomena than the microfollicular parenchymatous adenomatous goiter. The latter is the type of goiter usually observed at Berne, whereas the thyroids from the non-goitrous plains of northern Germany, as Isenschmid has pointed out, have larger follicles with a greater amount of colloid. The influence of the intermediate position of Basle in the goiter endemic is also manifested in its goiters, such that the thyroid follicles usually partake more of the macrofollicular type.

In performing partial thyroidectomy on cretins with goiter, it has been frequently noted in the surgical clinic at Berne that the extraglandular vessels are often very large. Professor de Quervain (30) refers to instances in which the thyroid arteries attained the unusual diameter of 10 millimeters and reports the instance of a boy in whom the inferior thyroid artery was larger than the usual carotid at that age. In his monograph on the histology of the cretin goiter, Wydler states that in almost half of the cretins operated upon in his series, the extraglandular vessels were of unusual size. He has described instances in which the inferior thyroid artery has attained the extraordinary size of the usual carotid or axillary artery.

This study, carried out at the suggestion and under the direction of Professor de Quervain, is concerned largely with the intraglandular vessels of cretin goiters. The necessity of an investigation of the finer blood supply of goiters of cretins is evidenced by the fact that many confused conceptions prevail concerning the vascularization of such glands, as well as concerning the nature of the cretin goiter in general. Though the investigation of the blood supply of cretin goiters has not proceeded further than the observation of the frequent presence of large vessels to the gland, a number of suggestions have been made to account for this phenomenon. Merke has suggested that a diminished permeability of the blood capillaries may not permit an adequate vascularization of the thyroid gland in cretins. Breitner believes that the atrophic epithelium of the cretin goiter is unable to utilize its blood supply. Even when the production of secretion is assured through a liberal supply of blood, Breitner states that this vascularization is of no avail in cretin thyroids, because the second important component of function, the removal of secretion, is inhibited by the accumulation of colloid in the gland.

The rarity with which the cretin goiter partakes of a colloid nature has already been

pointed out, and when Breitner refers to an inhibition or removal of secretion, due to the accumulation of colloid, it is apparent that he is speaking of an unusual type of cretin goiter.

A study of the intraglandular vessels of a fairly large number of ordinary adenomatous goiters and a few normal thyroids has also been made in order to establish a basis for comparison. Before presenting the results of this study, what is known concerning the vascularization of the normal thyroid and other forms of goiter will be briefly reviewed.

THE BLOOD SUPPLY OF THE NORMAL THYROID GLAND

The rich blood supply of the normal thyroid gland is well known. This small gland which receives the almost undivided flow of blood from its four arteries as well as from anastomotic vessels enjoys the provision of a multiple and liberal source of arterial supply not accorded any other organ of its size in the body. Tschueswsky calculated, in the dog, that the entire volume of blood coursed through the thyroid gland sixteen times a day. When the minute flow through the thyroid is compared with that established by Landergren and Tigerstedt for the brain and kidney in the dog, Tschueswsky estimated the blood supply of the thyroid to be twenty-eight times greater than that for the brain and 5.6 times more than that for a kidney.

A large number of investigations on the arterial circulation of the thyroid are to be found in the literature. How many of such studies were made on pathological material is, however, not always apparent.

Arteries. In his monograph on the diseases of the thyroid gland, von Eiselsberg stated that the inferior thyroid artery is the most important vessel of the thyroid. Latarjet and Alamartine concluded from their study of forty-five thyroids that the superior is the more important vessel. They state that the inferior thyroid artery is to be found only in the higher vertebrates. The caliber, course, and mode of division of the superior vessel, they found to be much more constant than for the inferior. Jaeger-Luroth was also of the opinion that the superior thyroid artery was the main vessel of the gland.

In the operation for goiter, as practised at the surgical clinic of Berne, in which the inferior thyroid artery is exposed and ligated routinely as an important preliminary to the resection or excision of goitrous tissue, the greater size of the inferior thyroid artery in goiter has been well established. In a study that includes a number of diffuse goiters made by Mastin at the Mayo clinic, in which measurements of the size of the extraglandular vessels are noted, the greater importance of the inferior thyroid artery in diffuse goiter is also apparent. Mastin found the diameter of the lumen of the inferior thyroid artery larger by a third, on the average, than that of the superior vessel. The average diameter of the inferior thyroid artery in his series was 2.78 millimeters and 1.87 millimeters for the superior. The largest inferior vessel measured 3.68 millimeters in diameter, and, for the superior, the largest measurement was 2.38 millimeters.

It may be that in the normal thyroid the superior is the more important vessel. From data available, however, this point cannot be definitely determined. In his monograph on the anatomy of the thyroid gland, Sobotta states that the inferior thyroid artery is usually the larger in the normal gland.

Anomalies. The superior thyroid artery, which takes origin as the first branch of the external carotid, is the less subject to variation. It has been known to be missing, but this is, indeed, a rare occurrence. In 437 cases, Dwight observed the inferior artery to be absent once on the right and five times on the left. Streckeisen failed to find an inferior thyroid artery on the left side four times in fifty-six instances. Its absence on the right was not observed. At operation Professor de Quervain (29) has found one of the inferior thyroid arteries to be absent in 2 to 3 per cent of cases.

Occasionally, an accessory artery known as the thyroid ima also supplies the thyroid gland with blood. In seventeen postmortem specimens injected in this series, such a vessel was found twice on the right side. An inferior thyroid artery was also present on the same side in each instance. In one of the cretin goiters removed at operation in this series, such an accessory vessel was present on both

sides. The inferior thyroid arteries were also present.

This vessel, usually described as the artery of Neubauer, was found twelve times in 120 instances by Streckeisen, and always on the right side. Gruber, who has given the vessel special study, finds that Neubauer described it in 1772, but states also that Haller accords its first description to Nicolai in 1725. In twenty-three observations of his own, in which a thyroid ima artery was present, Gruber found it only once on the left side. In two of these twenty-three instances, the corresponding inferior thyroid artery was found to be absent. In 1872, when Gruber's publication appeared, he was able to collect, including his own cases, 125 observations in which the presence of such a vessel had been ascertained. In only six of these instances, was it present on the left side. Gruber observed an instance in which the vessel was present bilaterally, and credits Hyrtl with a similar observation. In Gruber's case, the origin of the thyroid ima artery on each side was from the internal mammary; in the observation of its bilateral occurrence by Hyrtl, this accessory vessel originated in the innominate artery on the right, and from the aortic arch on the left. Its origin from the innominate artery, Streckeisen found to be the more frequent. Gruber refers to its inconstant source, and states that it has been found to take origin from the right and left common carotid arteries, from the right subclavian, the right thyreocervical axis, and even from the right transverse scapular artery.

Veins. Anomalies in the number and arrangement of the veins of the thyroid are considerably more frequent than of the arteries. There are more veins than arteries. The superior thyroid vein usually empties into the common facial vein; it may, however, empty into the internal jugular, or into the lingual vein. The inferior thyroid veins do not accompany the corresponding arteries at all, but empty by two to four branches that course downward into the internal jugular veins, or less commonly into the innominate veins or angulus venosus. A middle thyroid vein emptying by one or more independent vessels into the internal jugular vein on either side is also usually present. Its absence on one or both sides is, however, not an uncommon occurrence. When a thyroid ima artery is present, Sobotta states that a vein of the same name always accompanies it.

These veins build about the anterolateral aspect of the thyroid gland a veritable venous plexus, and they occasionally present at operation a rather formidable appearance. The veins of the thyroid have no valves.

Anastomoses of the arteries. The superior laryngeal artery, the first branch of the superior thyroid, perforates the thyrohyoid membrane, usually together with the superior laryngeal nerve, and establishes an important communication on the posterior side of the gland with the inferior laryngeal from the inferior thyroid artery. At the upper border of each lobe of the thyroid gland, the superior thyroid breaks up into its terminal branches, which usually are three in number. The main division crosses the superior pole of the gland, and courses over the anterior aspect of the lateral lobe, dividing into smaller branches that penetrate into the parenchyma. Another branch is directed medially over the cricothyroid membrane, and establishes an important communication with a similar division from the opposite side at the superior border of the isthmus. Occasionally, this branch may not take origin as a separate division of the superior thyroid artery, but springs from the first-named division. The pyramidal lobe, when present, receives its arterial supply from this vessel. The other terminal branch of the superior thyroid descends along the posterior border of the gland and regularly anastomoses with the inferior thyroid of the same side.

The inferior thyroid artery courses over the prevertebral fascia, crosses beneath and at right angles to the carotid vessels, and near the lower margin of the thyroid gland on its posterior aspect divides into two or more terminal branches. It has been known to be double throughout its entire extent from its point of origin in the thyreocervical axis. The lower branch supplies the lower pole of the gland, and frequently gives off a branch that crosses the trachea at the lower border of the isthmus and establishes a communication with a similar branch from the opposite inferior

Fig. 1. Showing adenomatous formation well developed in a cretin goiter of a girl of seven.

thyroid. The upper and main terminal division of the inferior thyroid artery sends several branches into the gland, gives off a few small branches to the œsophagus, anastomoses with the posterior division of the superior thyroid artery, and continues as the inferior laryngeal to establish an important communication with the superior laryngeal previously mentioned.

The importance of the collateral vascularization, established by the thyroid vessels with the ascending pharyngeal artery and tracheal and œsophageal vessels, is no slight one. Pettenkofer and Enderlen and Hotz have demonstrated, by injections into the ascending aorta in cadavers, that even after ligature of the four arteries of the thyroid at their points of origin a good injection of the thyroid vessels occurs, owing to this rich collateral inosculation (Fig. 5). These surgeons have put this method into practice and perform subtotal thyroidectomy by ligature of the four thyroid vessels. The preservation of the superior laryngeal and inferior laryngeal arteries is essential when such a procedure is practiced. Enderlen and the late Hotz interrupt the branches of the superior thyroid artery at the upper border of the gland in order to obviate injury to the superior laryngeal vessel. The inferior thyroid artery is tied as far laterally as possible, to preserve the inferior laryngeal artery, and at the same time to avoid injury to the recurrent laryngeal nerve.

The free anastomoses of the arteries of the thyroid takes place in the capsule of the gland.

Fig. 2. The arteries of the normal thyroid showing the chief anastomoses. (From Landström.)

There the branching of the arteries largely occurs, and large vessels within the gland are only infrequently observed. The follicular vessels terminate in rich capillary networks that completely surround the follicles of the gland. Few, if any, communications between the larger branches occur within the gland itself. Bérard (2) demonstrated such communications between the vessels within the gland by roentgenograms of injected specimens, but as Landström points out, it is difficult to determine, even with the stereoscope, whether vessels actually anastomose or merely pass by one another. Major was unable to determine the presence of any intraglandular anastomoses in the preparation of several corrosion specimens.

The blood supply of goiter. Special study of the arterial circulation of goitrous thyroids have been made by Bégoune and Terry and Delamere. The latter authors have investigated the arterial circulation of thyroid adenomata. They observed that contiguous adenomata frequently presented deficient filling of the vessels by the injection mass. When degenerative changes were present in the adenomata, the injection mass was regularly found within the degenerated areas, due to previous destruction of the vessels or to their increased friability.

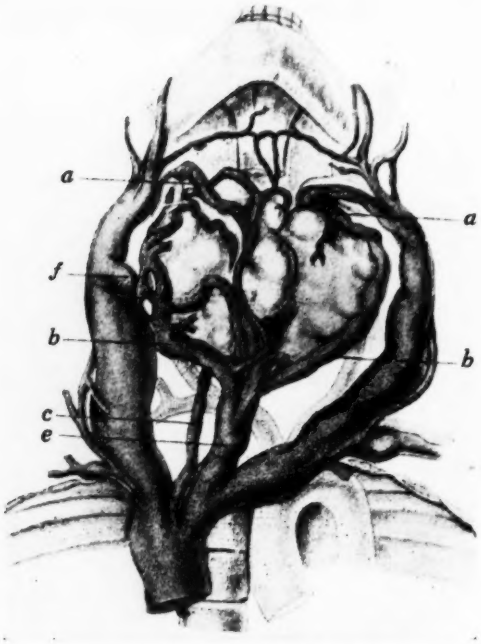

Fig. 3. The veins of goiter. The lack of correspondence between arteries and veins is apparent. a, Superior thyroid veins; b, inferior thyroid veins; c, thyroid ima vein; e, union of inferior thyroid veins; f, midthyroid vein absent on the left. (From Bérard.)

Anna Bégoune studied the intraglandular blood supply of the thyroid gland in diffuse hypertrophy and in colloid goiters exhibiting degenerative areas as well as in adenomatous and cystic goiters.

In her studies she found that the blood supply of the hyperplastic gland was much like that of the normal thyroid. In the colloid goiter, she observed no great variation from the normal. Where large accumulations of colloid were present, the vessels frequently were compressed, and the anastomoses between some of the vessels were erased. The blood supply of the cellular adenomata, Bégoune found to be the poorest. Here the finer vessels were the first to disappear. In cystic goiters, she found the zone immediately about the cyst to be poorly vascularized. Small vessels were occasionally observed to penetrate the cyst wall.

Fig. 4. The anastomoses of the thyroid arteries on the posterior side of the gland. The important inosculation between the superior laryngeal and the inferior laryngeal arteries is well shown. (From Pettenkofer.) (23)

METHOD OF STUDY

The source of the material for this study is comprised of operatively removed specimens as well as goiters obtained at necropsy. The injection of the latter was made possible by the courtesy of Professor Wegelin of the Pathological Institute of the University of Berne.

The method most frequently employed in this study was the intra-arterial injection of a gelatin carmine mass. A few venous injections with the gelatin carmine mass were also made.

The injection mass was brought into solution by gentle heating on a water bath to 50 degrees C. The injections were usually made with the removed specimen immersed in saline at a temperature of about 40 degrees C. Some injections were made with the thyroid *in situ*, in a few postmortem specimens. In the operatively removed specimens, the superior thyroid artery of the lobe best preserved intact was usually injected. Occasionally, the inferior was used, and sometimes both the superior and inferior arteries were injected. In the postmortem specimens, all the arteries were

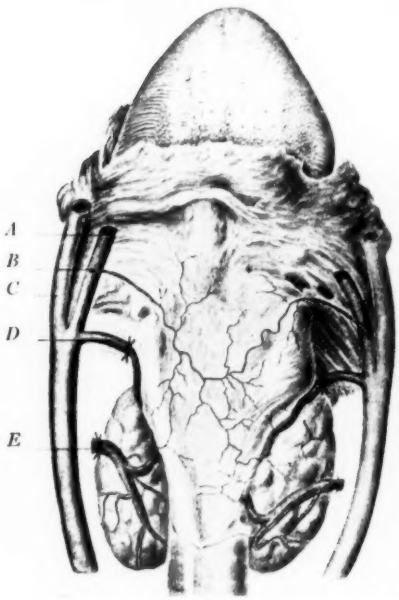

Fig. 5. Injection of four thyroid arteries through the collateral circulation of the gland after ligation of the four thyroid arteries. A, External carotid artery; *B*, Ascending pharyngeal artery; *C*, Internal carotid artery; *D*, Superior thyroid artery; *E*, Inferior thyroid artery. (From Enderlen and Hotz.)

Fig. 6. The branching of the thyroid vessels is well illustrated in this roentgenogram. The larger arteries are in the capsule. From a non-cretin goiter, aged 75.

usually injected. A metal syringe was employed, and gentle pressure was used. A manometer to determine exactly the amount of pressure employed was not used. On completion of the injection, the specimen was placed at once into ice water to permit of quick solidification of the injection mass.

India ink, diluted by the addition of about one-third as much water, was also used for the venous and intra-arterial injections of some operatively removed specimens. A little uncolored gelatin dissolved by heating was routinely added to this injection mixture.

Roentgen studies were made of a few thyroids after the intra-arterial injection of opaque media. Mercuric oxide and Hill's white mass were the contrast masses employed. In most instances, the size of the particles was such that the capillaries were not filled. Two pictures, in which the capillaries were nicely filled, were also obtained.

In one instance, a celloidin corrosion preparation of a cretin goiter obtained at necropsy was made.

The tissues employed for histological section were fixed in 4 per cent formalin. Small pieces from different parts of the gland were subsequently removed and embedded in celloidin. The cut sections (15 to 30 micra in thickness) were stained in each instance with hematoxylin and eosin, and also with van Gieson's stain.

SUMMARY OF RESULTS

Thirty-nine thyroid glands were injected in this study. Twenty-two of these represent operative material; in the remaining seventeen instances, the thyroid was obtained at autopsy. In only thirteen of these thirty-nine cases did the goitrous tissue come from individuals afflicted with cretinism. Ten of these goiters were obtained at operation from as many patients with cretinism. The other three concerned so-called "half-cretins." In two of these instances the thyroid was obtained at

Fig. 7. A corrosion preparation from a goiter of a "half-cretin." The vertical vessel is the ascending pharyngeal artery.

autopsy. The other twenty-six specimens consist of operatively removed euthyroidic adenomatous goiters and of similar goiters obtained at necropsy. Among the necropsy specimens, also, were five fairly normal thyroid glands.

The youngest patient in the series was a cretin girl of 7 years; the thyroid from the oldest subject was obtained at necropsy from a non-cretin aged 94. The oldest known cretin in the series was 64. Frequently, the age could not be determined, however, because of the mental status of the patient.

The measurements of the diameter of the chief vessels was not determined in all cases. The greater size of the inferior thyroid artery was almost uniformly noted. Diameters of 9 millimeters were observed for the inferior thyroid artery of several cretin goiters. The largest measurement for the superior vessel was 6 millimeters. In one large non-cretin goiter, removed at autopsy, the left inferior artery, which supplied a large substernal lobe, had a diameter of 9 millimeters.

The inferior thyroid artery was found to be absent in only one instance (left side) in the seventeen necropsy specimens dissected. The superior thyroid artery was never absent, but in two instances, both times on the left side, it was very small and could be traced only with difficulty. In both these instances, the vessel lay almost in the midline over the thyroid cartilage and approached the lateral lobe from its medial aspect. In one case operated upon, the superior thyroid artery was double throughout its visible extent in its approach to the left lobe of the gland. In a patient of 55 who died of hypertension, all the vessels were so sclerosed that the finest glass cannula could be introduced only with considerable difficulty. As was previously stated, an accessory thyroid ima artery was observed twice in dissected postmortem specimens, both times on the right side. In one case operated upon, its bilateral occurrence was noted.

In the injected postmortem specimens, a good injection of the tracheal, laryngeal, and œsophageal vessels was constantly observed.

In a few injections made into the thyroid veins of operatively removed specimens, the greater friability of the veins over that of the arteries was noted. Rupture of the vessels and dissemination of the injection mass into the adjacent tissue was not infrequently observed (Fig. 8). Though seen, also, after intra-arterial injections, it followed with considerably less regularity.

Only one corrosion preparation was made in this study. Careful inspection of the specimen shows that a few anastomoses of the so-called interlobular arteries are present. True, no anastomoses of the larger divisions of the primary branches were made out.

In one cretin patient of 46 years, in this series, marked pulsations of the thyroid vessels could be seen and felt. A small artery, running obliquely from right to left, pulsated vigorously and could be seen through the skin (Fig. 9). At operation, this was found to be a branch of the main division of the right superior thyroid artery that ran obliquely across the isthmus to establish a communication with the left inferior thyroid artery. Such an anomalous anastomosis has previously been described by Bégoune and Landström (22).

The basal metabolism of this patient was normal (+1 per cent), and no clinical symptoms of hyperthyroidism were present. The

Fig. 8. An injection onto the superior thyroid vein of a cretin goiter. Dissemination of the injection mass into the gland tissue because of the friability of the veins.

Fig. 9. The pulsating thyroid of a cretin with goiter. The anomalous artery running obliquely from right to left can be seen beneath the skin.

left lobe which was used for injection weighed 58 grams. Its superior thyroid artery was 6 millimeters in diameter and that of the inferior 9 millimeters. Grossly, this goiter was distinctly adenomatous on cut section.

Doubler has already reported from this clinic four instances in which such pulsating vascular goiters were present in children with some physical features of cretinism and low basal metabolic rates. Occasionally, a few concomitant symptoms suggesting hyperthyroidism were present. Pathologically, these were all diffuse goiters in which the diagnosis of diffuse hyperplasia (exophthalmic goiter) was made in some instances.

Sections of injected specimens colored with van Gieson's stain make beautiful preparations for microscopic study, especially when India ink is employed for the injection. The glandular elements present a greenish-brown appearance, and the connective tissue spaces and the blood vessels are bright red. The intimal layer of the blood vessels is stained a dark brown, while the muscular layer takes the same hue as the connective tissue. The blood in the vessels, when not replaced by the injection mass, is a pale brown. The colloid in the follicles is stained a pale brown and occasionally a deep brown.

Williamson and Pearse state that they rarely were able to inject the capillaries by arterial injections. In only one out of each twenty instances were they able to get nice capillary injections. I encountered no difficulty in this regard and usually obtained sections in which the capillaries were well-filled. Occasionally, areas were present in which a few of the smaller vessels had escaped injection.

In the normal thyroid gland, connective tissue processes are seen only where blood vessels are present. Flint states that in the fetal thyroid, these processes may constitute septa that divide the gland into fairly definite structural units. Employing the same dissection of partially digested thyroids of adults, he was unable to determine the presence of such definite structural units. Williamson and Pearse have recently referred to a "functional unit" in the gland, which they describe as a lymphatic sinusoid.

Major recognizes in the thyroid gland certain vascular units, of which the follicular is the smallest. An aggregation of an inconstant number of follicles constitutes the lobular or

Fig. 10. An arterial bud in a capsular artery. The intimal thickening of the artery beside it is marked. (van Giesson's stain.) A gelatin-carmine injection mass is in the lumina of the vessels. (×70)

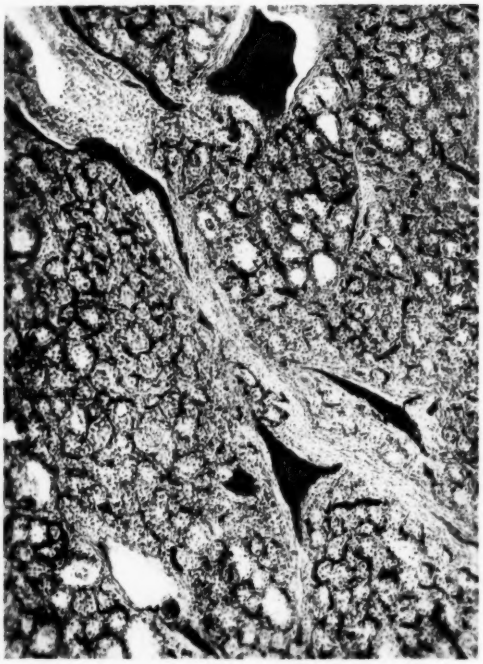

Fig. 11. The capillary network in a diffuse cretin goiter injected with India ink. Vessels of the second order are apparent in the fairly dense stroma. (Hæmatoxylin and eosin stain.) (×70)

next smallest unit. Collections of lobules, marked off from similar groups of lobules by fairly dense connective tissue processes, form the next larger vascular unit, which Major calls the lobular unit; it does not correspond to a definite structural unit. The first and largest vascular, Major recognizes as the lobe itself.

Each follicle has a small artery of its own, the follicular artery, which ends in a rich capillary network completely surrounding the follicle. These follicular arteries or vessels of the fourth order, in turn, are divisions of the lobular vessels, which run in a somewhat larger connective tissue process between aggregations of follicles. In denser strands of connective tissue septa, vessels of the second order, a rather arbitrary division, give off the lobular arteries of the third order, already mentioned. The vessels of the first order are represented by the anastomosing arteries in the capsule.

In the normal thyroid gland, Major found that the capillaries of the follicular network averaged 0.008 millimeter in diameter. This measurement for the follicular arteries was 0.0125 millimeter; for the lobular vessels, 0.030 millimeter; and for the arteries of the second order, 0.100 millimeter. The arteries of the first order in the capsule had an average diameter of 0.150 millimeter.

The difficulty of determining any average size for the larger orders, of arteries in goiter, is readily appreciated when one considers the varying size of the chief vessels as well as of the goiter itself. However, even a cursory examination of a few sections would serve to indicate that these measurements of the normal will not hold for adenomatous goiter.

Numerous determinations of the diameter of the various orders of vessels have been made of each preparation used for histological study. Near the surface of the gland, in the capsule, variations from 0.170 to 2.210 millimeters were observed. The latter large capsular artery was found in the non-cretin goiter previ-

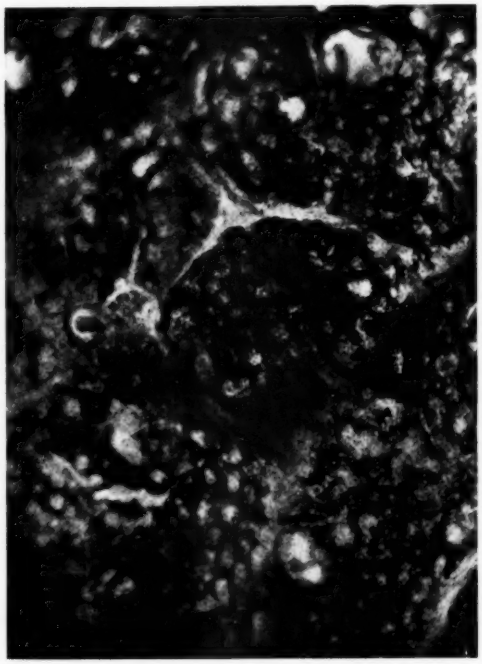

Fig. 12. The capillary network in beginning adenoma formation (from another area of same gland as Figure 11).

Fig. 13. An atrophic area in a cretin goiter. These micro-follicular acini are frequently seen in cretin thyroids. The proliferation of the connective tissue and the scarcity of the capillary vessels is apparent. (Carmine-gelatin injection mass—hæmatoxylin-eosin stain.) (×70)

ously mentioned, in which the left inferior thyroid artery had a diameter of 9 millimeters. In many of the cretin goiters, measurements of 0.680 millimeter were frequently seen. Diameters for these surface arteries of a millimeter or slightly more, were not infrequently observed.

For vessels of the second order in the dense strands of connective tissue within the gland, variations of from 0.085 to 0.425 millimeter were found. Considerable variation in the size of such vessels was constantly present, even within the same gland. Measurements varying from 0.116 to 0.348 millimeter for such vessels, in different septa of the same gland, were obtained in one section of a cretin goiter.

Variations between 0.029 to 0.085 millimeter were found in the diameters of interlobular vessels. Most of the measurements were grouped between 0.034 and 0.058 millimeter for these vessels, in both the cretin and the ordinary adenomatous goiter. In a few cretin goiters, a measurement of 0.072 millimeter was obtained not infrequently, for this diameter.

The most constant finding for the diameter of follicular arteries was between 0.023 and 0.029 millimeter in both cretin and non-cretin goiters. Variations, however, between 0.016 and 0.0435 millimeter were observed in this series. Measurements of 0.0145 millimeter for the follicular artery were common in the normal glands examined.

The diameter of capillaries in the follicular network was determined in several areas in each preparation. The most constant finding for the diameter of the capillaries was from 0.0087 to 0.0145 millimeter, in areas where the acini were distended by accumulation of colloid. This diameter was occasionally found to be as low as 0.0003 millimeter. In some

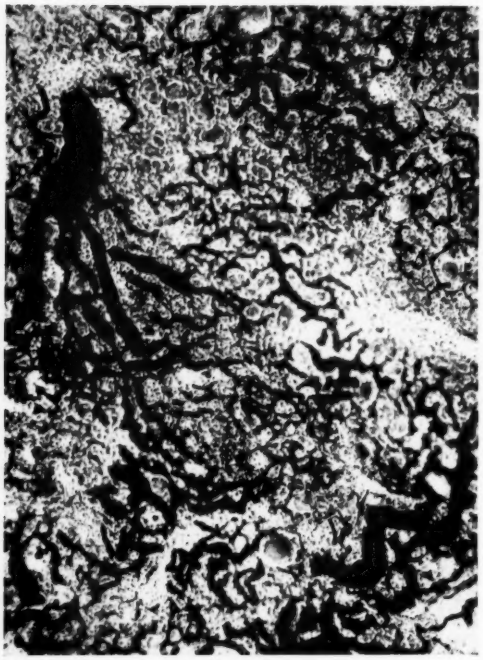

Fig. 14. A section from the pulsating goiter of the patient shown in Figure 11. The large branching vessel is an artery of the second order from which the inter-lobular and the follicular arteries in turn are given off. The giant-like structure of some of the capillaries is apparent. (Gelatin-carmine injection mass. Haematoxylin and eosin stain.)

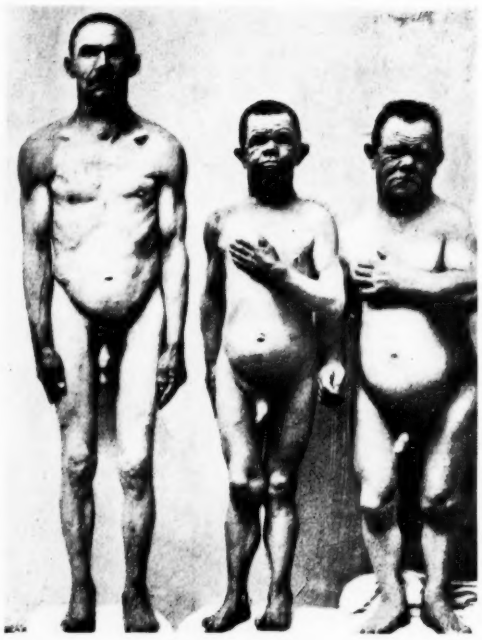

Fig. 15. Cretinism with and without goiter. a, cretin with goiter. Height 158 cm. Genital glands and pilary system normal. b, cretin with atrophied thyroid. Height 133 cm. Testicles atrophied; maldeveloped pilary system. c, Ditto. Height 135 cm. (From de Quervain, Reference No. 29.)

areas of sections of both cretin and non-cretin goiters, where connective tissue proliferation was present in abundance, capillaries frequently were absent or were present only here and there in an isolated fashion, springing from larger branches, as small twigs growing from the trunk of a fairly large tree. In some of the cretin goiters, giant capillaries 0.029 millimeter in diameter were not infrequently observed,[1] completely surrounding the follicles. Lesser diameters of 0.020 to 0.023 millimeter were not uncommon. Capillaries of this diameter were also seen in sections of some ordinary adenomatous goiters.

No attempt has been made to make a quantitative anatomical study of the vascular system in these thyroids. Variations in the size of the follicles, the arrangement and distribution of the connective tissue, and other factors, affect the disposition of the vessels in such a manner that the study would be without value. The determination of the factors that occasion deviations in the vascular system from the normal is far more important.

A study of the sections colored with van Gieson's stain, in which the relation of the connective tissue processes and the vessels in them to the acini can easily be traced, has convinced me that the size and distribution of at least the smaller vessels in the gland are intimately related to the changes in these connective tissue processes. In glands or in areas of a gland, where large accumulations of colloid are present, the connective tissue spaces in which the vessels run are very much

[1] Merke has recently conjectured, on theoretical grounds, that cretin goiters with such large arteries and veins must have a large and important capillary bed, there being no direct arteriovenous communications. (F. Merke, Deutsche Ztschr. f. Chir., 1928, cxx, 70.)

narrowed and compressed. The capillaries in the interfollicular network are in consequence collapsed. Where collagenous processes of connective tissue are present in abundance, and where marked fibrotic changes occur, the vessels also suffer as a result. Here capillary communications become erased, and follicular arteries are not infrequently found occluded by the constricting connective tissue. Then again, in areas of such glands where these changes and increases in the interstitial tissue are less prominent, dilatation of the smaller vessels may also be seen. In those thyroids, where there is no great deviation from the normal in the amount and quality of the interstitial tissue, the capillaries of the gland have the arrangement present in the normal. In areas of epithelial hyperplasia such as are seen even in the cretin goiter, as well as in the euthyroidic-adenomatous goiter, where the disposition of the connective tissue is more like that seen in the normal gland, the capillary network surrounding the follicles is also more like the normal.

The poor blood supply of adenomata or degenerating adenomatous areas presenting cystic or other changes, is well known. It has already been pointed out that the cretin goiter has no pathognomonic pathological picture. It is usually adenomatous in character and, as the studies of Wydler (43) and Wegelin (40) have shown, cretin goiters show degenerative changes earlier and in excess of what occurs in the ordinary adenomatous goiter. Similarly, here a poor vascularization of adenomatous areas, with marked connective tissue proliferation or other degenerative change, is to be expected.

Getzowa has studied the histology of atrophic thyroids of cretins without goiter. In several specimens, she was unable to ascertain the presence of capillaries in the connective tissue stroma. The marked sclerosis of the interstitial tissue present in such glands would, of course, account for the scarcity of the vessels observed.

Degenerative changes in the walls of the arteries themselves were frequently seen in this study. These changes are practically limited to the intima. Intimal thickening of such grade that the vessel was occluded or the lumen almost obliterated, occurs not infrequently. The capsular and arteries of the second order are chiefly concerned, but the follicular and interlobular arteries do not escape. The wall of one large capsular artery presenting this degenerative phenomenon was 0.290 millimeter in thickness.

The two larger orders of arteries in the thyroid frequently have a very thin muscular layer, such that these arteries may be indistinguishable from the accompanying veins. These latter vessels in the thyroid are regularly present without a muscular layer, the wall of the vein being constituted by intima and adventitia only. The interlobular and follicular arteries, however, usually have a fairly well-developed muscle coat.

In the two larger orders of arteries, the presence of thickening and degenerative changes in the intima serve to establish the identity of the arteries. Splitting of the elastica interna in the larger arteries near points of division is also not an uncommon occurrence.

Gutknecht has described the finding of regressive changes in the vessels of adenomatous goiters exhibiting degenerative phenomena as a common event. Isenschmid studied the thyroid gland of childhood and states that arteriosclerotic changes in the vessels are not uncommon after the first year of life. Necrosis of the elastic fibers in the intima, followed by hyaline connective tissue changes and calcification, he observed frequently in the arteries of the thyroid of children. This process he found to occur with greater regularity in the thyroids from Berne, in the goiter endemic, than in thyroids of children from Kiel, where goiter is not endemic. Cora Hesselberg has even found arteriosclerotic changes in the arteries of the thyroid of the newborn.

Small projections from the intima into the lumina of some of the arteries were often seen in the adenomatous goiters of both cretins and non-cretins examined in this series. These buds are most frequently seen in the middle-sized arteries and especially near points of division. They appear to consist of the intima alone (Fig. 10). Horne was the first to describe them in the fetal thyroid and in the arteries of adenomatous goiters. Schmidt subsequently showed that these buds were a

fairly normal occurrence in the arteries of the normal thyroid. Wegelin, Getzowa, and de Coulon have already described these buds in the arteries of cretin goiters. Wydler failed to observe them. Isenschmid cautions, however, that their presence can be determined only in thin sections. They do not occur in the veins. Their significance is not known.

The large extraglandular vessels seen in these cretin goiters probably represent a compensatory effect—an effort to bring as good a blood supply as possible to the adenomatous areas. It has previously been pointed out that adenomatous goiters have larger vessels than those seen in diffuse enlargement of the thyroid.

The enlargement of the afferent and efferent vessels in tumor formation appears to be characteristic. It is especially to be seen in rapidly growing tumors such as sarcomata as well as in large tumors of various kinds (hypernephroma, lipoma, etc.). In intra-abdominal tumors to which the omentum has become attached, marked enlargement of the omental vessels is even occasionally observed.

Adenomatous formation in the thyroid is quite generally looked upon as being a neoplastic process of benign nature. In endemic goiter areas, the incidence of adenomata in the thyroid is, of course, far greater than in regions free from goiter. Wegelin has found that more than 75 per cent of patients over 40 years of age coming to necropsy at Berne, show adenomatous formation in their thyroids. In patients over 80 years, this figure reaches 100 per cent. He also points out that even in goiter-free areas, the incidence of adenomata increases with age. In both the normal thyroid as well as in the adenomatous goiter, therefore, interstitial connective tissue changes commensurate with the age factor are to be expected. Consequent and parallel alterations in the disposition of the smaller vessels necessarily follow.

There appears to be no direct relation between the size of the goiter and its arteries. In the cretin goiters, however, large extraglandular arteries accompany lesser enlargements of the thyroid than in the ordinary adenomatous goiter. A diameter of 9 millimeters for the inferior thyroid artery of the non-cretin goiter was observed only once in this series. Its occurrence obtained in the instance of a very large goiter, the weight of which was not ascertained. Such a measurement was observed several times for cretin goiters, in which the lobe obtained for injection weighed only 58, 70, or 95 grams.

The call upon the vessels by a growing tissue alone would, therefore, inadequately account for the larger size of the arteries of the cretin goiter. The excessive response in the form of unusually large vessels manifested in such patients probably also represents, in part, the answer to the demand of a physiologically hypo-active tissue for more blood. The giant capillaries previously described probably find their origin in the same explanation.

That the thyroid tissue of cretins is relatively inert is demonstrated in their low metabolic rates, as well as in the negligible iodine content of such tissue. The diminished biological activity of tissue from cretin goiters has also been well shown by the tad-pole feeding experiments carried out by Branovacky in this laboratory. Thyroid tissue from cretin goiters showed a markedly decreased tendency to influence the rate of development and growth of tad-poles as contrasted with the effect of the feeding of normal thyroid tissue.

An effective call for a greater blood supply, however, can come only from tissue capable of hypertrophy. The hyperfunctioning tissue of diffuse hyperplasia, undoubtedly, is also able to create such a demand. In the atrophic thyroid glands of cretins without goiter, such large vessels are not encountered.

In the diffuse hyperplasia of exophthalmic goiter, in which the thyroid arteries are usually obtain than are those of adenomatous goiters, the smaller lumina of the vessels are probably more than compensated for in the increased rate of circulation. Blalock and Harrison have recently shown that the cardiac output is increased in dogs who are given thyroid extract. In thyroidectomized dogs, they found the cardiac output diminished, and postulate that the same probably occurs in myxœdema. Although a diminished rate of circulation or diminution in the cardiac output has not been demonstrated in cretins

over what obtains in normal individuals, cretinism probably partakes in this particular of the features of myxœdema. Professor de Quervain has already pointed out that these are factors for which the arterial circulation of the cretin goiter must also compensate.

SUMMARY AND CONCLUSIONS

What is known concerning the blood supply of the normal and the pathological thyroid gland has been reviewed. The normal thyroid gland is provided with a more liberal and free source of arterial flow than is any other gland of its size in the body. In goiter, the inferior thyroid artery is the larger and the more important vessel. An accessory or thyroid ima artery occurs in about 10 per cent of instances, and usually on the right side. Free anastomoses of the chief arteries of the gland occur in the capsule. Anastomoses between the arteries within the gland itself are thought not to exist, but a few such communications were observed in our one corrosion specimen.

The alteration in the disposition of the smaller blood vessels in goiter is intimately related to and dependent on the changes in the connective tissue stroma in which the vessels run. In adenomatous goiter, where such changes are common, deviations from the normal size and distribution of the interlobular follicular and capillary vessels are frequent. In the goiter of the cretin, where degenerative changes are especially prevalent, transition from the normal arrangement of these smaller vessels is particularly likely to obtain. Degenerative changes in the vessel walls of arteries of all orders are common in adenomatous goiters.

The large extraglandular vessels so frequently seen in cretin goiters represent a compensatory attempt to insure a good blood supply to a benign neoplastic process of a hypofunctioning tissue, in which the alterations in the stroma have made a normal nutrition impossible. In areas of cretin goiters, where no departure from the normal is present in the quality and quantity of the connective tissue stroma, giant capillaries may obtain in the interfollicular network. Less frequently, such dilated capillaries are also observed in non-cretin adenomatous goiters.

The vascular system of the goiter of cretins is not peculiar to cretin goiters alone. Its counterpart, though in less degree, is observed in the vessels of ordinary adenomatous goiters. With its biologically inert tissue, the goiter of the cretin is not able to eke out of its abundant blood supply a nutrition sufficient for normal function.

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ADENOMA OF THE KIDNEY

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THE conventional description of adenoma of the kidney may be summed up as follows: The tumor is small; it presents no clinical symptoms, hence, has no clinical significance; and it occurs most frequently in kidneys affected with interstitial nephritis. This, in a general way, expresses the views of Israel, Thomson-Walker, Young, and many others. On the other hand, Judd and Simon are of the opinion that clinical symptoms are striking in those instances in which large, benign adenomata of the kidney are present.

In this paper will be considered only the large benign adenoma—a rare type of renal neoplasm. Its rarity combined with its unusual size should constitute full justification for the following report.

CASE REPORT

Miss F. M., age 24 years. Family history was negative. Patient has always been in very good health. In June, 1920, she noticed an enlargement on the right side of the abdomen but she did not consider it of sufficient importance to consult a physician. Three or four months later she called the attention of her family physician to the swelling because of its size. No pain or discomfort or any general systemic disturbance occurred until within the last few weeks when there were transient, slight aching pains and discomfort on the right side. The mass, according to her statement, progressively increased in size and at no time were large quantities of urine passed.

Examination (H.L.K.) January 22, 1922, disclosed a large tumor mass on the right side, the most prominent part of which was just above the umbilicus and extended a little beyond the median line, three fingerbreadths above the top of the umbilicus and one fingerbreadth inside of the anterior superior spine. The mass was smooth, not tender, was freely movable, and could be displaced without difficulty. When displaced it moved toward the kidney area, but deep inspiration moved it back to its original position. It could also be displaced downward into the pelvis. Patient was advised to go to the Presbyterian Hospital, but did not take this advice. She returned two years later, the condition being practically the same. She entered the hospital on March 25, 1924.

Physical examination (two years after first examination) showed patient to be well nourished and apparently in good health.

Abdominal examination disclosed a large, firm tumor mass which occupied almost the entire right half of the abdomen, extending from about 2 inches above the pelvic brim up to the costal arch and medially to the midline. The mass was globular in shape, was not attached to the anterior abdominal wall, and was about 10 inches in diameter. It was not noticeably respiratory motile and seemed to be attached posteriorly to the kidney region. There was no evidence of fluctuation and pain was not present on manipulation.

Pelvic examination showed the uterus pushed deep into the true pelvis, anteversed with the cervix pointing directly downward. The uterus was freely movable and apparently was not connected with the broad ligament. The ovaries were not palpable.

Blood examination showed red blood cells, 4,900,000; leucocytes, 6,700; hæmoglobin, 95 per cent. Blood pressure: systolic 115, diastolic 75. Urinalysis of voided specimen showed urine cloudy, acid reaction, albumin, some blood cells, no sugar, pus 3 plus, no casts, but some epithelial cells.

Cystoscopic examination showed the bladder and ureteral orifices normal. Both ureters were catheterized without difficulty or obstruction. A prompt flow of urine was obtained.

Examination of catheterized specimens showed:

	Leucocytes per c.mm.	Cultures	Urea	Casts	Red blood cells
Bladder	50	Sterile		0	++
Right Kidney	90	Sterile	1.05%	0	++++
Left Kidney	70	Sterile	.87%	0	0

Thalein test showed:

	Right per cent	Left per cent
First 15 minutes	5	12
Second 30 minutes	8	18
Total 45 minutes	13	30

Roentgen-ray examination: The right kidney region is covered by a large, soft parts shadow which extends from the eleventh rib to the crest of the ilium and suggests a much enlarged kidney shadow. The right catheter extends to the level of the second lumbar vertebra; it curves mesially and overlies the spinous processes of the third, fourth, and fifth lumbar vertebræ. The kidney outline is normal. The left catheter extends to the level of the third lumbar vertebra and is in normal position. No urinary stone shadows are seen. The examination disclosed no bone change.

A right pyelogram (Fig. 1—film taken with the patient lying down) shows the right kidney pelvis incompletely filled; it lies at the level of the first lumbar vertebra in the upper part of the large, soft

parts shadow previously reported. This shadow is again visualized and extends from the eleventh rib to 1 inch below the crest of the ilium, and practically fills the right side of the abdomen. The catheter is deviated to the midline.

A second pyelogram (Fig. 2—film taken with the patient standing) shows the kidney pelvis at the level of the fourth lumbar vertebra. There is a better filling which shows a little clubbing of the calyces. The soft parts mass now extends from the third lumbar down into the bony pelvis to the level of the ischial spine; it covers the area from the midline of the right ilium to the left border of the sacrum, measuring 18 by 24 centimeters. The catheter extends from the middle of this shadow and along the right border of the spine, probably because the mass has rotated over the ureter instead of pushing it to one side as before. The right lobe of the liver is distinctly visible, its lower border lying 6 centimeters below the eleventh rib shadow. The kidney pelvis and calyces lie at the upper margin, the outline of the shadow produced by the kidney and the tumor.

On the basis of these findings a diagnosis was made of a large tumor in the right kidney which shifts with the change of the position of the patient.

Operation was performed March 28, 1924, ethylene anæsthesia being used (H.L.K.). The usual oblique lumbar incision was made. A large, round tumor mass was felt which was attached to the lower pole of the kidney, the lower margin reaching to the brim of the pelvis. The mass was delivered through the incision and measured 10 inches in diameter. A distinct line of demarcation between the tumor mass and the kidney substance could not be made out. Removal from the kidney was effected by resection, the line of incision being through the kidney substance and the inferior calyx. There was no line of fibrous demarcation. The edges were approximated and sutured with heavy catgut. Because of the great mobility of the kidney, as a result of the weight of the tumor which was attached to the inferior pole, it was decided to do a nephropexy. A cigarette drain was left in the wound. The patient left the hospital 19 days later, after an uneventful recovery. Seventeen months later she was operated upon for fibroids of the uterus. She was seen within the past 3 months at which time examination of the abdomen was completely negative and there was no sign of recurrence, 8 years after the onset of her trouble and 4 years after her operation.

Description of specimen: The tumor mass, including a small portion of the kidney, weighs 760 grams. It is oval in shape and is 12 by 15 by 15.5 centimeters in its greatest diameters. It is entirely encapsulated by a tough, blue white membrane in which there are three vessels ½ by 1 millimeter in diameter. The capsule strips easily from the tumor leaving a rather smooth uniform surface which represents a second capsule. A small portion of the kidney, 1 by 7 centimeters, covers the upper pole of the tumor and is definitely enclosed in between two layers of the outer capsule. The tumor mass is uniformly yellow and soft throughout. It is everywhere surrounded by an inner tough blue capsule, ½ to 1 millimeter in thickness, to which the soft tumor tissue is attached. There are two or three islands of bluish cartilaginous material scattered throughout the soft tumor tissue. Grossly, there are numerous blood vessels near the central part of the tumor which center about one of the cartilaginous islands. The tumor tissue is uniform in consistency throughout, being as solid at the center as at the periphery beneath the capsule. Grossly, there is no evidence of degeneration.

Microscopic sections: The kidney tissue is unchanged and contains no evidence of tumor tissue. The capsule of the tumor is composed of dense fibrous tissue.

Sections from the tumor mass show it to consist of masses of cells in more or less alveolar arrangement on a connective tissue framework. The cells are cuboidal, or hexagonal in shape. The nuclei are large, the chromatic material abundant, and the nuclei are markedly prominent. There are a few mitotic figures scattered throughout. In some parts of the section the cells form short tubules with and without lumen. These cells are similar to each other and are usually cuboidal. Connective tissue is denser in one-fourth of the slide, and in it are embedded masses of cuboidal and polygonal cells, but all these cells bear relation to a basement membrane. Along one edge of the section there is granular structureless material resembling products of degeneration. The microscopic structure of the tumor suggests an adenoma of the alveolar type with some tubule formation.

Histological diagnosis: adenoma of the kidney.

REVIEW OF THE LITERATURE

The case described, added to those found in the available literature, brings the total number up to 17. Of these 17 cases, 8 were females, 7 males, and in 2 cases the sex was not stated.

AGE

The age incidence does not seem to be a very constant one. The youngest patient on record, a female, 11 months of age, was reported by Czerny, and Kynoch's patient was 16 months of age. The oldest case, a male, 70 years of age, was reported by Binney. It can readily be seen that the age incidence has no bearing on the cases.

CLINICAL DATA

The majority of these cases were found in the older literature and were reported at a time when urological cases were not carefully

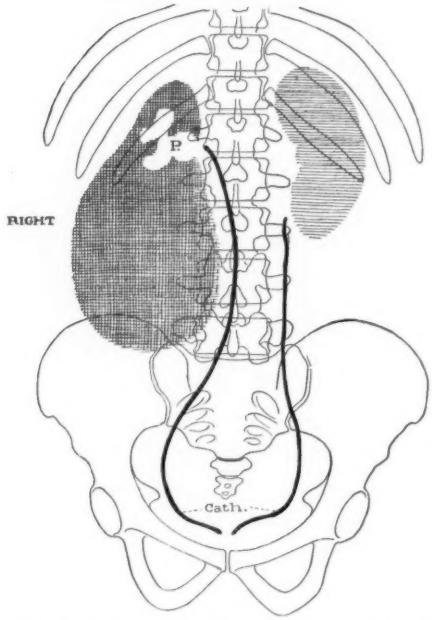

Fig. 1. Pyelogram made with the patient lying flat. The pelvis is opposite the first lumbar vertebra.

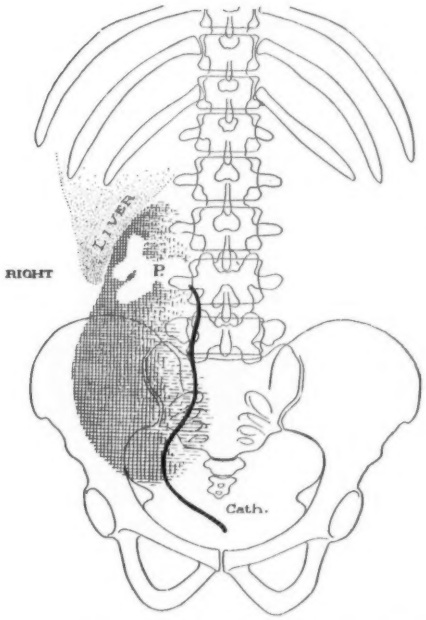

Fig. 2. Pyelogram taken with the patient standing. Note descent of tumor into the right iliac fossa. Pelvis situated opposite the third lumbar vertebra. The edge of the liver is well below the costal arch.

studied by means of the roentgen-ray, of cystoscopy, of ureteral catheterization, and of the pyelogram; hence, the symptomatology is vaguely expressed, and many of the reports are decidedly incomplete. Some of the cases were simply autopsy specimens and contain little or no data.

The one constant symptom in this group is the presence of an abdominal tumor.

Blood in the urine is mentioned in 8 cases, pain in 6, and anæmia in 3. The tumor was on the right side in 10 cases, on the left side in 4 cases, and in 3 cases no mention was made of the side.

In the pre-pyelogram days physical examination was the only means of establishing a diagnosis. In the case reported by Judd a filling defect was found in the pyelogram and the diagnosis of tumor was based on the picture. In the case reported here the tumor originated from the lower pole of the kidney and grew down into the iliac fossa and the pelvis. There was no encroachment on the kidney pelvis, hence, no filling defect, such as is usually found in tumors of the kidney, occurred. The interesting thing in the pyelogram was the dislocation of the pelvis. The X-ray film taken with the patient in the standing position showed the descent of the kidney pelvis into the iliac fossa. The suspicions entertained prior to the physical examination that the tumor was of renal origin were confirmed by the examination.

Nevertheless, before the patient came under our observation a diagnosis of ovarian cyst had been made. The size of the tumor is the only distinctive sign that the kidney is the site of a benign tumor; therefore, a pre-operative diagnosis, unless the distinctive sign is taken into consideration, is likely to be wrong.

The case herewith reported was seen within the past 3 months, 8 years after the onset of her trouble and 4 years after the operation. She is well and examination showed no sign of recurrence. One of the patients reported by

ADENOMA OF THE KIDNEY

	Author	Sex	Age	Hæmaturia	Pain	Anæmia	Tumor	Side	Urine	Cystoscopy	Pyelogram	Pre-operative diagnosis	Operation	Post-operative diagnosis	Results
1	Albert	F	42	+	+		+	Rt.	Blood, pus	Neg.		Papillary adenoma	Nephrectomy	Papillary adenoma	Recovery.
2	Bell	F	39			+	+	Rt.					Nephrectomy	Alveolar adenoma	Died in 16 hours.
3	Binney (by personal communication)	M	70		+		+	Left	Neg.	Neg.			L. nephrectomy	Adenoma	Good recovery—died 5 yrs. later with pneumonia.
4	Czerny	F	11 mo.	+			+	Left					Nephrectomy	Adenoma	Peritonitis—died in 2 days.
5	Foulds-Braasch	M	48	+			+	Left						Adenoma	Recovered—died 9 years later.
6	Judd	F	51	+	+		+	Rt.		Neg.	Longitudinal filling defect		Nephrectomy	Adenoma	Up 13th day.
7	Keyes	M	49	+			+	Rt.					Nephrectomy	Ca.? Adenoma	Well 1 year later.
8	Kretschmer and Doehring	F	24				+	Rt.		Neg.	Dislocation kidney pelvis		Resection	Adenoma	Well 4 years later.
9	Kynoch	..	16 mo.				+	Rt.					Nephrectomy	Adenoma	Well 6 weeks later.
10	Morris	M	48	+	+		+	Rt.		Neg.			Nephrectomy	Adenoma	Well 1 year later.
11	Morris	F	35	+		+	+	Rt.					Nephrectomy	Adenoma	Well 10 years later.
12	Morris	F	46		+		+	Rt.					Anterior nephrectomy	Tubular adenoma	Excellent recovery.
13	Morris	M	55	(Au sp	tops ecim	y en)	.	Clinica abse	l data nt						
14	Morris	F	3 yr.				+						Nephrectomy	Adenoma	
15	Norman	M	53	(Au sp	tops ecim	y en)	+	Rt.						Alveolar adenoma	
16	Schonborn	NS	2 yr.				+							Adenoma	Recovery.
17	Weir	M	35	+	+	+	+	Left					Transperitoneal nephrectomy	Adenoma	Recovery.

Morris, a female, 48 years of age, was alive and well 10 years after the operation.

LARGE BENIGN ADENOMATA OF THE KIDNEY

Large benign adenomata of the kidney are not of frequent occurrence. Of 114 renal tumors, collected by Binney in reviewing the literature, 10 were found to be adenomata of various types. Barney found 3 adenomata among 74 renal tumors in a series collected at the Massachusetts General Hospital. Garceau mentions 4 large papillary adenomata among 42 renal tumors at the Massachusetts General Hospital and Boston City Hospital in 10 years. Judd has collected 7 cases of benign adenomata from the literature and added one of his own. According to Morris, benign new-growths in the kidney scarcely form 6 per cent of renal tumors. Of 51 collected cases Aldibert found 48 were malignant and only 3 benign. Between January 1, 1901, and January 1, 1923, 283 patients with tumor of the kidney were operated upon in the Mayo Clinic. Benign tumors (adenoma, lipoma, and angioma) were present in only 3 cases.

PATHOGENESIS

The pathogenesis of simple adenomata is obscure and uncertain. They are found both in the healthy kidney and in the kidney with chronic interstitial nephritis. Some arise, probably, as Albarran suggests, from

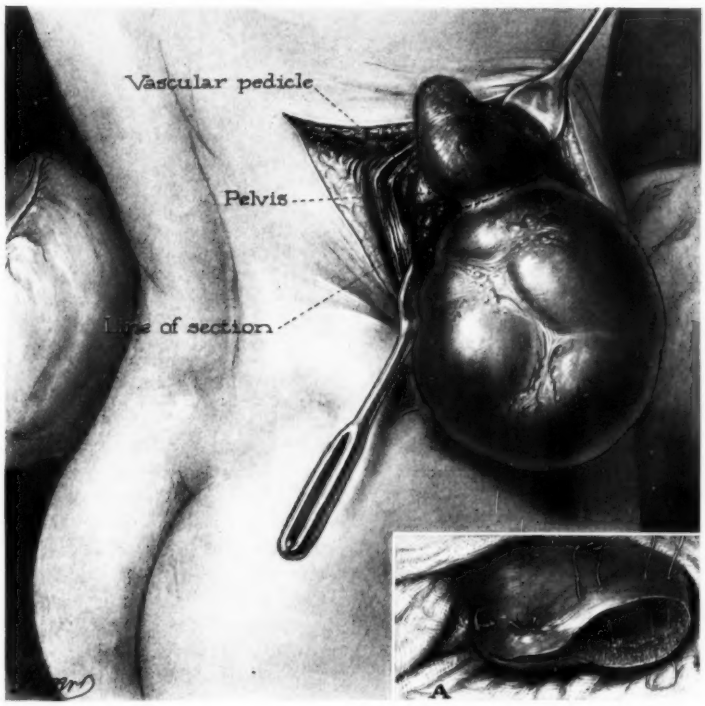

Fig. 3. Showing line of section. A, Insert showing method of closure.

"rests" of the renal tubules, or, as Pilliet indicates, from functionally isolated elements due to an error in development; others possibly from remnants of the wolffian body. That all adenomata do not arise from the same source is evident. Morris states that the epithelium in one of his cases is typically renal and in long tubes, whereas James Bell reports a case in which the epithelium is composed of "large polygonal cells with a clear homogeneous cytoplasm" distinctly different from normal kidney tissue cells. MacCallum believes that the tumor cells are the offspring of cells destined to form kidney substance but diverted to the formation of a tumor at an early stage of development. Israel, in his monograph on surgery of the kidney and ureter, quotes Borst as follows: "The term adenoma has so far no theoretical significance, as the proof that it takes its origin from the renal tubules has not been proved. One has much more the impression that it perhaps takes its origin from an unused part of the *Nierenanlage*."

SIZE

Renal adenomata may vary in size from less than 1 millimeter to 20 centimeters in diameter. The smaller ones are grayish-red nodules, sharply demarcated and encapsuled, usually lying in the cortex just under the capsule, but occasionally found in the medullary portions. They may be single or multiple, solid or cystic, and consist of small tubules packed closely together, or ramifying glandular structures in which the cells are much smaller than those of the convoluted tubules. Glomeruli have not been found. Symptoms are lacking and frequently their presence is only ascertained at autopsy.

When adenomata reach a size large enough to form tumors they give rise to symptoms of pain, pressure, discomfort, and sometimes

hæmaturia. The large tumors are more frequently seen past middle life. Nevertheless, 6 cases have been reported in which the patients were under 25 years of age, 4 of these being under 3 years (Czerny, Kynoch, Morris, Schonborn). The tumor was palpable in every instance. Hæmaturia was present in 8 cases (Albert, Czerny, Foulds and Braasch, Judd, Keyes, Morris (2), Weir), and pain in 6 cases (Albert, Binney, Judd, Morris (2), Weir). In this collection women were more prone to the affection than men, and the right kidney was more often the site of tumor than the left.

The large tumors may be surrounded either by a fibrous capsule or by a capsule composed of a thin layer of renal tissue. This is determined by the seat of formation of the new-growth, whether in the kidney substance or on its surface. When of capsular origin, trabeculæ may divide the tumor into two or more sections. The tumor substance may be hard or soft, light gray to yellow, hæmorrhagic, solid, or cystic.

For the purpose of discussion these tumors may be divided into three groups according to their structure: (1) tubular, (2) alveolar, (3) papillary. The tubular form resembles adenoma of other organs. It is characterized by masses of cylindrical epithelium in tubular arrangement with or without a central clear space. The alveolar form has its cells arranged in alveoli on a fibrous connective tissue framework. The papillary form is probably not a distinct entity but merely shows papillary projections into microscopic cavities. It is the form most frequently seen.

DIAGNOSIS

The diagnosis of renal adenoma is difficult. A freely movable, painless, slow-growing mass in the hypochondrium, movable with respiration, is suggestive of a benign tumor. Roentgen-ray examination may show the mass. Unless the tumor encroaches upon the renal pelvis, or compresses it, a normal pyelogram may be obtained, especially if the tumor originates from the lower pole. The examination of urine may not give any additional information. On the other hand, the presence of gross bleeding, which may be sudden in onset and associated with pain in the kidney region, and the presence of a palpable mass, should be evidence enough of the presence of a renal tumor. Furthermore, the fact that the growth has attained a large size in a leisurely way covering months, justifies the pre-operative diagnosis of benign tumor. In the present case, because of the long duration of time during which the patient noticed the growth, the absence of adhesions, and its mobility, the diagnosis of benign tumor was made with a leaning toward a solitary cyst. The importance of establishing the correct diagnosis is self-evident. To do a nephrectomy when a partial nephrectomy will do just as well, seems hardly justified. If it is possible to be reasonably certain that the tumor is benign, a large part of the normal kidney can be left behind as was done in this case. There was no difficulty in spite of the fact that resection went through the inferior calyx.

When the tumor is removed, the question whether it is benign or malignant is easily settled, but histological sections are absolutely necessary to establish a diagnosis of the type of tumor. A histological diagnosis, it should be remembered, is often fraught with difficulties. But without the histological sections the clinical diagnosis is never so dependable that a positive statement can be made.

SUMMARY

1. A case of benign adenoma of the kidney is reported, and the patient is well and free from recurrence, 8 years after the tumor was first discovered and 4 years after the operation.

2. Benign kidney tumors of the type described are rare.

3. Renal neoplasm of this type renders itself well to resection of the kidney.

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TUMORS OF THE SALIVARY GLANDS

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ANGIOMATOSIS OF THE SALIVARY GLANDS

ANGIOMATOSIS of the salivary glands is a rare condition but by no means unique. There are several cases recorded in surgical literature; Virchow in 1889 refers to two cases of parotid angiomata. The condition occurs mostly in children, and in those cases which have been described in adults, there is generally a history of the condition having been present since birth. For example, Gascoyen described a case of angioma of the parotid in a man aged 44 years. The tumor was congenital and gradually increased as age advanced to such a size that it eventually caused the death of the man by suffocation. Clement Nicory described a case of an infant aged 9 months which was operated upon by Clogg in which the whole of the right parotid gland was involved, and complete excision was impossible.

I have seen only one case and that occurred in a male infant aged 3 months who was admitted to the Belgrave Hospital for Children, with a large tumor the size of a pigeon's egg, situated just in front of the angle of the lower jaw on the right side. The tumor was increasing in size, it was more or less circumscribed, and the skin was of a purplish color transmitted from the tumor beneath it. The tumor was excised by means of a ⅃-shaped incision; there was no definite capsule and hæmorrhage was free. The tumor was definitely lobulated and macroscopically resembled fat, with many dilated and tortuous vessels running in every direction through it. Microscopically, the glandular structure of the lobules was seen to be replaced by a delicate network of capillaries, the walls of which consisted of a single layer of endothelium.

Magnac described a case of angioma of the submaxillary gland in a girl aged 5 years. A swelling had been present below the right side of the lower jaw since birth, and at the age of 5 it commenced to increase in size. It was thought to be a retention cyst of the submaxillary gland. After excision, the tumor was found to be an angioma which was in close contact with the gland but had not penetrated it.

ADENOMATA

Adenomata of the salivary glands are rare; they occur more frequently in the parotid than the other glands. They are always encapsulated and may be cystic or solid. They are usually alveolar in structure and reproduce the acini of the gland. There can be no doubt that these rare tumors show a tendency to undergo malignant change into adenocarcinoma.

MIXED TUMORS OF THE SALIVARY GLANDS

These tumors are most common in the parotid gland and are characterized by the presence of spaces containing material resembling cartilage (Fig. 1). They have been called by a variety of names: embryoma, endothelioma, or mixed tumor. There has been, and still is, an active controversy as to the nature of these tumors. They were at first thought to be

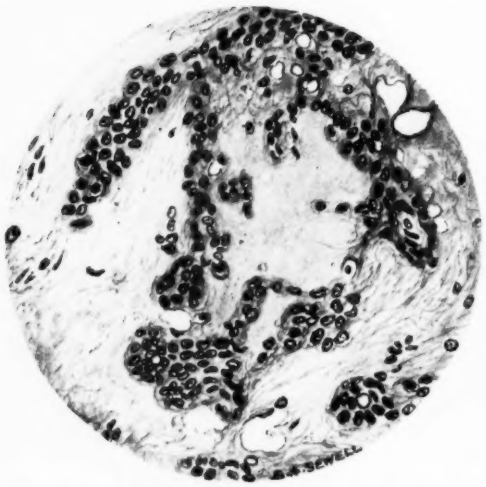

Fig. 1. Low power view of section of mixed parotid tumor, showing area resembling cartilage.

Fig. 2. High power view (×800) of mixed parotid tumor. The epithelial cells can be readily seen.

purely epithelial in origin. Virchow considered that the cartilage was formed by a process of metaplasia from connective tissue, while Cohnheim stated that it was a remnant of the branchial arches which became displaced during fetal life.

It was Wartmann who first set forth the endothelial theory; he considered that the polyhedral cells were derived from endothelial cells of the lymphatic vessels. The endothelial nature of mixed parotid tumors was widely accepted except in France. Today the endothelial theory has been abandoned altogether, for the cells show no definite endothelial characters under the higher powers of the microscope and more delicate contrast staining. At the present time the consensus of opinion is that the vast majority of so-called mixed tumors are entirely epithelial in nature. This conclusion is largely due to the investigations of Kennon and Fry.

The tumors are derived most frequently from the ducts of the glands but in a few cases from the secreting cells.

Fry considers that the mucinous material, which is such a prominent feature of most of these tumors, is a true secretion of mucin from the tumor cells and that this is only an exaggeration of a normal function of the gland cells.

No cartilage is to be found in these tumors; but in the substance which has been described as cartilage, the matrix is formed by a change in the mucin of the tumor, whereby it loses its fibrillar appearance and its power of staining deeply with special dyes. Fry used mucicarmine and was able to demonstrate the fact very conclusively. The cells of these tumors under the high power of the microscope are definitely epithelial (Fig. 2).

Although most pathologists believe in the epithelial nature of these tumors, there are still some who cannot agree to classify all mixed tumors of the salivary glands under that heading.

Ewing considers that the endothelial origin of mixed tumors of the salivary glands has been entirely disproved, but adds: "No single source of the mixed tumors meets all the requirements. Some are distinctly adenomatous and probably arise from the acini and ducts of the gland in which they are well incorporated. Others are encapsulated or extraglandular and take the form of basal cell or adenocystic epithelioma. These probably arise from misplaced and occasionally embryonal portions of gland tissue. Branchial

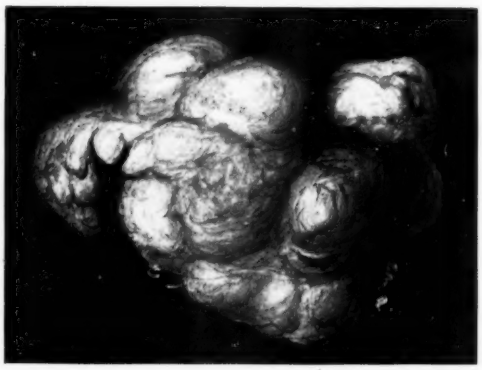

Fig. 3. Mixed parotid tumor after excision.

remnants may possibly be connected with this group." This conclusion from such an eminent authority may be said to represent the present state of our knowledge with regard to these tumors; and I think that the term "mixed tumors" should still be used to designate them, although the majority are certainly epithelial in nature.

Mixed parotid tumors are equally common in either sex and know no age incidence; they may occur in children or in old age.

These tumors are usually situated in the superficial portion of the parotid gland, are freely movable in the gland substance, are coarsely nodular (Fig. 3), and vary in consistency in different parts. The facial nerve in its course through the parotid gland is deeply placed (Fig. 4) and hence is not pressed on by these tumors unless they undergo malignant change. They have a definite capsule and outside this the gland tissue is somewhat compressed to form an extra pseudo-capsule. This fact is important from the point of view of treatment. If excision is undertaken and the tumor is removed, a parotid fistula rarely results; this is due to the fact that the compressed gland substance around the tumor prevents any escape of secretion.

These tumors show a definite tendency to recur even after a long interval and are therefore considered by many surgeons to be potentially malignant. Burrows considers that the most satisfactory method of treatment is operation combined with radium irradiation.

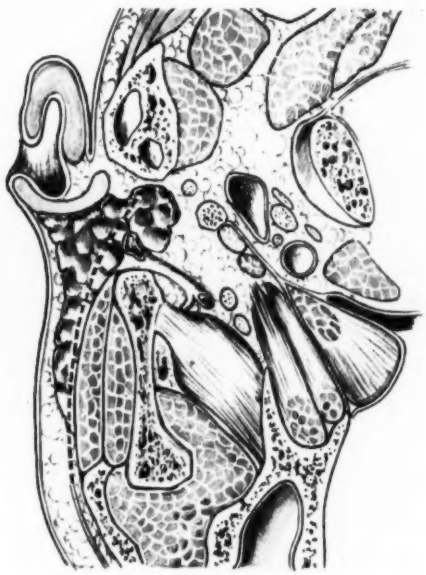

Fig. 4. Coronal section through the parotid gland showing the course of the facial nerves.

This may be so, but great caution should be observed in radium treatment and small doses of radium only should be employed at operation. The radium tubes should be left in the cavity after removal of the tumor. I have seen two cases in which radium was employed and complete paralysis of the facial nerve ensued.

As a rule these so-called mixed tumors are of slow growth and frequently many years elapse before the patient seeks advice or will consent to operation. Rapid increase in size of the tumor or the onset of facial paralysis may be the determining factor which induces a patient to seek treatment. Unfortunately, both these signs are usually consequent on malignant change.

During the years 1900–1925, 52 cases of parotid tumor have been operated upon at King's College Hospital. In 40 cases the tumor was removed and on histological examination was found to be a mixed tumor, while in 12 cases the tumor was found to be malignant.

Of the 12 cases of malignant disease of the parotid, 7 occurred in men and 5 in women. The average age of the 12 patients was 58

Fig. 5 (left). Mixed parotid tumor.
Fig. 6. Mixed parotid tumor undergoing malignant change causing facial paralysis.

Fig. 7. Mixed tumor of the submaxillary gland of 30 years' standing. It was removed without difficulty.

years. The facial nerve was involved in every case and the average length of life after involvement of the facial nerve was 16 months. The longest was 3 years and the shortest 6 months.

Of the 40 cases of "mixed tumor" I have been able to trace only 35 cases. In 7 cases (20 per cent), there was a history of recurrence of the tumor which necessitated a further operation. In one case three subsequent operations were performed. In 5 cases death occurred within 10 years of the operation from malignant disease of the parotid. In 23 cases there has been no recurrence and the patients have remained in good health.

With regard to malignant disease of the parotid, the treatment of radium or deep X-ray therapy does not seem to lengthen life to an appreciable extent.

Some of the early cases of malignant disease of the parotid were treated before the introduction of X-ray or radium, while the later ones were given combined treatment.

McFarland quite recently reviewed the after history of 90 cases of parotid tumor. He seems to be of the opinion that carcinoma very rarely develops in a mixed tumor and states that when such a change occurs its proof is very difficult on histological grounds.

Stoehr and Risak analyzed 71 cases of tumor of the parotid which have been seen in Professor Hochenegg's clinic for a period of 22 years. Of 59 cases of mixed parotid tumor radical removal was performed in 50, and of these 39 were traced. It was found that 32 had remained free from recurrence after one operation. In the remaining 7 cases recurrence took place up to 9 years later.

Whatever the pathogenesis of mixed tumors of the salivary glands may be, it is quite certain that recurrence after operation is quite common, and therefore these tumors should be considered as potentially malignant.

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A STUDY OF THE INJECTION TREATMENT FOR VARICOSE VEINS[1]

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THIS combined clinical and laboratory study of the injection treatment for varicose veins was undertaken for the purpose of evaluating the method in our own minds. The incidental appearance of some unusual complications has prompted us to submit the results of our study for publication.

The history and technique of the treatment have been described by Dunbar, Forestier, Hanschell, K. Linser, P. Linser, McPheeters, Meyer, Sicard, and others. A variety of solutions has been employed, the more important of which are: sodium chloride, 15 to 25 per cent; dextrose or glucose, 50 to 66 per cent; and quinine-urethane, consisting of quinine 4 grams, urethane 2 grams, and distilled water 30 cubic centimeters; mercuric cyanide, .01 grams per cubic centimeter; metaphen (Schussler); calorose; mercury bichloride, 1:5,000 to 1:100; phenol, 5 per cent; sodium citrate, C.P. in distilled water aa. 8 grams; alcohol, 30 per cent; tincture of iodine; and iodine in the form of Pregl's solution.

Each solution has acquired its exponents and its opponents. Sicard and Forestier (7) have used sodium salicylate to good advantage, but Jorgensen reports a case of salicylate intoxication following an injection of 5 cubic centimeters of 20 per cent sodium salicylate. To avoid such reactions, Sicard advises a preliminary test dose of 1 cubic centimeter of the 20 per cent solution. Delater noted from the use of salicylates reactions of a vagotonic character about once in every 200 cases. These reactions consisted of cold sweats, the slowing of the pulse, nausea, and vomiting. The reactions from quinine were of a toxic nature, consisting of itching and miliary eruptions. Anaphylactic manifestations, more common in women, were also noted after quinine injections. Delater controlled the mild reactions by injections of epinephrine. Crampy pains, indolent sloughs, limitation of dosage, and toxicity of the compounds have constituted obstacles to the universal acceptance of the injection treatment for varicose veins.

However, when K. Linser, in 1924 (15, 16), introduced the use of 15 per cent sodium chloride as a sclerosing substance, the attention of many men was attracted to the method. We have been using chemically pure sodium chloride in a 20 per cent concentration for the past year at the Michael Reese Hospital with interesting results. The solutions have been double autoclaved in spite of the statements by Linser (16) and Kottmaier that 15 per cent sodium chloride solution is sterile after 48 hours by virtue of its high concentration. The solution has proved very effective in the thicker walled veins of men. The existence of ulceration or eczema cruris has been no contra-indication to its use. In fact, the best results have been obtained in this type of case. In the thin walled veins of women with an abundant fat deposit in the subcutaneous tissues of the legs, on the other hand, difficulties have been encountered. Here, the indolent and painful sloughs commonly described as complications of the technique occurred in two cases; one patient had two sloughs. Two were due to the extravascular injection of a small amount of the solution; but the third occurred following an injection that was definitely into the vein. When the latter slough was removed, bleeding resulted and recurred frequently.

The appearance of a slough due to an extravascular injection can easily be predicted since the patient complains of severe burning at the site of injection, and the area becomes white and insensitive to pain. Hanschell has recently described a type of slough occurring about 1 inch above the point of injection, in spite of an accurate injection into the vein. He directs the needle upward, and it is possible that the slough appears at the point where the stream of the injected fluid impinges against the wall of the vein. Such sloughs healed readily following the injection of hypotonic salt solution. We have recently been injecting hypotonic salt solution about the point of injection, when, immediately following the intravenous use of 20 per cent sodium chloride, a leak has

[1] From the Department of Surgery, the Leon Klein Fund, and the Nelson Morris Institute for Medical Research of the Michael Reese Hospital.

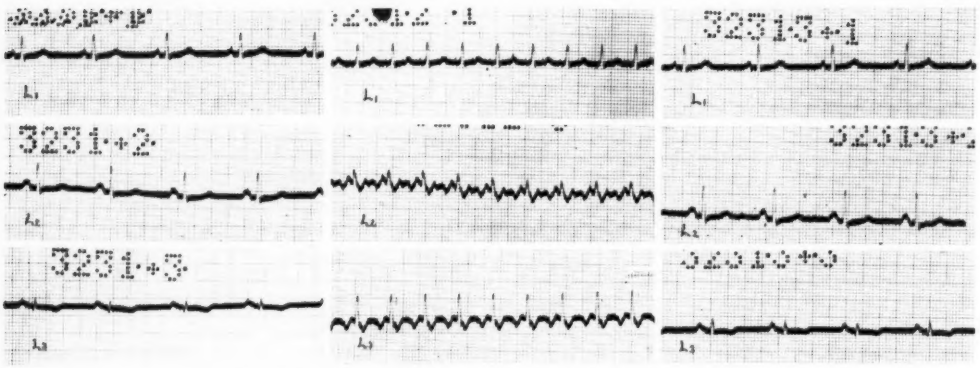

Fig. 1. M.T. 5 cubic centimeters of 20 per cent sodium chloride was injected into the internal saphenous veins of each leg. A, One hour before injection: Sinus rhythm. Rate 68. P-R interval 0.18 seconds. Inversion of T_3. The auricular waves in leads two and three show some notching. B, One hour after injection: Auricular flutter. (2 to 1.) Ventricular rate 150. Auricular rate 300. T_2 is inverted, likewise T_3, although it is difficult to say with certainty concerning the latter because of the super-imposition of the auricular waves. There is an increase in amplitude of the main deflection, R, with considerable notching in lead three. C, Twenty hours after injection: Sinus rhythm. Rate 68. P-R interval 0.16 second. The following differences are noted between this curve and curve A.: Increase in the amplitude of R_3, notching of the auricular wave in lead two with an increase in its amplitude in lead three, and shortening of the P-R interval by 0.02 to 0.04 second.

been suspected. Our previous method of making a cruciate incision in the blanched area with a view to allowing some of the solution to escape was of very little avail, but this method apparently offers possibilities.

In our work, patients have been admitted to the hospital for 24 hours for a study of the heart, kidneys, and blood pressure preliminary to treatment. The fruits of this procedure are evidenced in the following case (Fig. 1):

M. T., aged 60 years, a baker, was admitted to the Michael Reese Hospital on the service of Dr. Greensfelder on January 7, 1928, complaining of varicose veins of both legs and an ulcer on the right leg. Varicosities of the right leg developed in 1919 at which time they were operated upon. Shortly after the operation, varices of the right leg re-appeared and veins of the left leg also became enlarged. Two weeks before admission an ulcer appeared on the right leg. Urination during the day about three times and at night twice. Hæmorrhoidectomy had been done 30 years previously. History was otherwise negative.

Examination of the right leg disclosed pigmentation of the skin on the medial surface with a small ulcer, 2 by 1 centimeter, in the darkened area. There were varicosities of the internal saphenous vein. The left leg also had varicosities of the internal saphenous vein. The heart was 10 centimeters to the left of the midsternal line; rhythm was regular; no murmurs; aortic second sound slightly accentuated. Blood pressure was 150-110. The lungs and abdomen were negative. Examination of the urine showed: reaction, acid; specific gravity, 1.034; albumin, sugar, acetone, absent; and microscopic examination negative. White blood count was 7,500. Temperature 99.8 rectally, respirations 18 and pulse 80.

On January 7, 1928, 4.5 cubic centimeters of 20 per cent sodium chloride was injected into the right and 4.5 cubic centimeters into the left internal saphenous veins. One hour after injection, temperature per rectum was 99.2 degrees; respiration 18; pulse, 76 and irregular. Five hours after injection, temperature per rectum was 100.4 degrees; respiration, 20; pulse, 80 and regular. Twenty-four hours after injection, temperature per rectum was 99 degrees; respiration, 18; pulse, 64 and regular.

On January 9, 1928, 5 cubic centimeters of 20 per cent sodium chloride was injected into the right and 5 cubic centimeters into the left internal saphenous veins. One hour before injection, temperature was 98.2; respiration, 20; pulse, 68. Electrocardiogram (Fig. 1, A) discloses "Sinus rhythm. Rate 68. P-R interval 0.18 seconds. Inversion of T_3. The auricular waves in leads two and three show some notching which may be taken as an indication of slight interference with the spread of the conduction impulse through the auricle." One hour after injection, temperature was 98.4; respiration, 22; pulse, 150 and irregular. Numerous extra-systoles were noted. Electrocardiogram (Fig. 1, B) discloses "Auricular flutter (2 to 1). Ventricular rate 150. Auricular rate 300. T_2 is inverted, likewise T_3, although it is difficult to say with certainty concerning the latter because of the superimposition of the auricular waves."

Four and one-half hours after injection, temperature was 98; respiration, 24; pulse, 140. Numerous

extra-systoles were noted. The urine was negative. January 10, 1928: Fourteen hours after injection, temperature was 98.2; respiration, 18; pulse, 96. Numerous extra-systoles occurred at regular intervals. Sixteen hours after injection, electrocardiogram (Fig. 1, C) discloses: "Sinus rhythm. Rate 68. P-R interval 0.16 second. The following differences between this curve and the one taken before the injection of the salt solution are noted: Increase in amplitude of *R3*, notching of auricular wave in lead two, and increase in amplitude in lead three. Shortening of P-R interval by 0.02 to 0.04 second."

Twenty-one hours after injection, pulse was 72 and regular. On January 18, 1928, the ulcer was healed.

The explanation of this phenomenon is difficult. Howell says: "The sodium salts in the blood and lymph take the chief part in the maintenance of osmotic pressure. . . . The sodium ions have in addition a specific influence on the state of the heart tissue. Contractility and irritability disappear when they are absent; when present alone in physiological concentration in the medium bathing the heart muscle they produce relaxation of the muscle tissue." Whereas, Starling says: "It has been suggested that the rhythmic contractions of the heart muscle may be the result of constant chemical stimulus of the inorganic salts present in the blood plasma, sodium acting as a stimulus to contraction; while calcium salts are necessary for the maintenance of relaxation. . . . The exact significance of these different salts for the functions of cardiac and other forms of muscular tissue, though they have been the subject of many detailed investigations, must still be an open question." Dr. W. S. Priest of the electrocardiographic laboratory of the Michael Reese Hospital has offered the suggestion that the change from normal rate to auricular flutter in this case might be the result of a change in the concentration of the electrolytes of the blood. He adds that since the most marked change is concerned with the auricle and since slight abnormalities were noted in the auricular waves of the control curve, it seems possible that the effect obtained by the injection of the salt solution was based on its action on an already damaged tissue. The fact that the effect was not a specific reaction to sodium chloride was determined 2 weeks later, January 24, 1928, when curves were taken on the patient before and after 10 grams of sodium chloride diluted with two glasses of water were administered to the patient by mouth, with the following results:

Before sodium chloride was given by mouth: "Sinus rhythm. Rate 71. P-R interval 0.20 seconds. Inversion of T_3. P_3 is notched. Occasional ventricular ectopic beats arising from two foci, one in the left and one in the right ventricle." Two hours after 10 grams of sodium chloride was given by mouth: "Sinus rhythm. Rate 65. Aside from the difference in the rate and the absence of ectopic beats, the curve is the same as the previous one."

To determine the effect on concentrated salt solutions on normal hearts, dogs were injected intravenously with 20 per cent sodium chloride, 20 per cent potassium chloride, and 10 per cent calcium chloride in 3 cubic centimeters, 3 cubic centimeters, and 2 cubic centimeters, amounts respectively. Electrocardiograms were made before and after the injections with such negligible variations in the curves that we hesitate to attribute them to the introduction of the solutions, since variations of such minor character are frequently found in dogs.

The lesson to be learned from the case reported is that patients of advanced years with a slight tendency to cardiac irregularity may be adversely affected by sodium chloride injections.

Another patient, who had varicosities of all of the superficial veins of both legs but no evidence of involvement of the deep venous system, complained of symptoms of "intermittent claudication" following treatment of his varicose veins. After walking about 50 feet, he would experience cramps in the muscles of his legs and was unable to proceed for a period of a few minutes. These symptoms disappeared in the course of 6 months and he then experienced such difficulty only occasionally, especially after he stood in one position for a long time. We feel that the rapid obliteration of the superficial venous system in this patient may have played some part in the appearance of his symptoms, although these complaints were present to a minor degree before the injection treatment but were perhaps not given sufficient credence in our zeal to attribute them to the most obvious pathology, the varicose veins.

Because of the reputed painlessness of the injections and the absence of sloughs following

extravascular leakage, glucose solutions are now being used by many clinics. To test the relative merits of glucose and sodium chloride, we did a series of injections on dogs with 20 per cent sodium chloride and 50 per cent glucose in commercially prepared ampules. We realized that in such experiments, the dilatation and slow blood current of varicosities would not be imitated. On the other hand, Regard describes the greatest reaction from the sclerosing injections as occurring in the intima. According to the work of Berntsen, the histology of varicose veins consists in most cases of an atrophy of the circular muscle of the media, at first compensated by an hypertrophy of the elastic fibers but later followed by an atrophy of these fibers without notable effect on the intima. We, therefore, felt that a fair comparison of the relative effects of the two solutions could be made, especially if the effect of stasis was partially imitated by injecting distalward and applying a pressure pad over the site of injection for 48 hours. Accordingly, 4 veins were injected with 4 cubic centimeters of 20 per cent sodium chloride solution and removed consecutively 3, 3, 7, and 14 days after the date of injection; and 5 veins were injected with 50 per cent glucose solution, 2 cubic centimeters intravascularly and extravascularly in the first case, and 5 cubic centimeters intravascularly in the 4 remaining cases. The second injection of sodium chloride was also made intravascularly and extravascularly for comparative purposes. When excised this vein was found surrounded by a dark area of hæmorrhage; whereas the extravascularly injected glucose vein, which was removed 7 days after injection, was merely embedded in fibrous tissue with no gross evidence of slough. The remaining glucose-injected veins were removed 12, 17, 23, and 30 days respectively after the date of injection. Transverse sections were taken from three points of each vein and stained with hæmatoxylin and eosin, and Weigert's elastic tissue, and van Gieson stains.

Only one of the veins injected with glucose was thrombosed. A section of that vein is shown in Figure 4. It was removed 17 days after injection and has a well organized and canalizing thrombus firmly attached to the wall of the vein. The intima is entirely absent and the thrombus is attached to the inner layer of elastic fibers. A comparison of this photomicrograph with that of a section of vein removed 14 days after injection with sodium chloride solution (Fig. 3) discloses a somewhat better preservation of the elastic fibers in the former, especially those adjacent to the thrombus. A comparison of both of these sections with that from a normal vein (Fig. 2) from the same dog as that from which the section of Figure 3 was removed, demonstrates the effect on the elastic tissue of the media of the sclerosing injections in these cases. The fibers lack the length and feathery distribution seen in the normal (Fig. 2). Both of the injected veins have an increase of fibrous tissue in the media. In the adventitia there is practically no change. From these sections, one gains the impression that in addition to the intima, the elastic tissue of the media also suffers as a result of the sclerosing injections. This finding was not present in all of the veins presenting changes; but the possibility of its occurrence is well demonstrated by the photomicrographs submitted.

The sections of the veins injected with sodium chloride demonstrate a regular progression of the process of thrombosis from a hyalinized clot with prominent lines of Zahn in the specimen removed 3 days after injection, to beginning fibrosis in the specimen removed 7 days after injection, and to well advanced organization and canalization in the specimen removed 14 days after injection. The intima in the earlier sections is almost completely absent; the subendothelial tissues have a fairly heavy deposit of polymorphonuclear leucocytes; the media contains a variable amount of elastic tissue and its muscle layers are cloudy. The adventitia has a marked accumulation of red blood cells and leucocytes. There is evidently an endophlebitis and periphlebitis with a less marked involvement of the muscular layer. The periphlebitis may be due either to the extension of the process through the entire wall of the vein or to the presence of the solution in the vasa vasorum. The elastic tissue of the adventitia in this case is practically unchanged. The same may be said for the elastic tissue of the adventitia of all of the other veins

Fig. 2. Portion of cross section of normal vein of dog showing elastic tissue of media. Elastic tissue and van Gieson stain ×275.

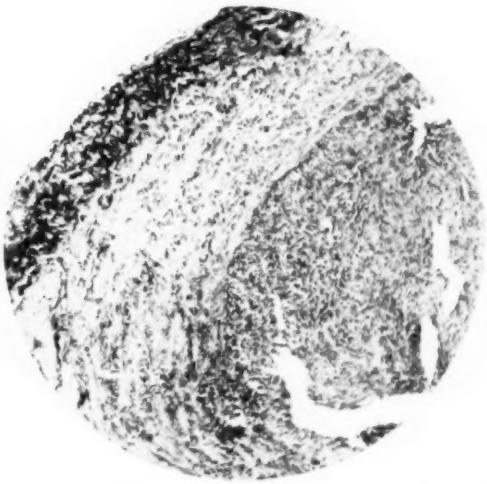

Fig. 3. Portion of cross section of vein from same dog as shown in Figure 2, 14 days after injection with 20 per cent sodium chloride. Elastic tissue and van Gieson stain ×120.

injected. The elastic tissue of the media in these sections, however, is markedly fragmented.

In the sections taken from the vein removed 7 days after injection with sodium chloride, the intima is almost entirely absent with a well formed thrombus filling almost the entire vein. The media appears somewhat disrupted with groups of red blood cells and leucocytes between the connective tissue and muscle cells, especially beneath the area of attachment of the thrombus. The elastic fibers are present in good amount and fairly well preserved except where the clumps of red blood cells and leucocytes are found. The adventitia contains a liberal sprinkling of small round cells and an occasional polymorphonuclear leucocyte.

In the sections taken from the vein removed 14 days after injection with sodium chloride (Fig. 3), a well organized thrombus undergoing canalization is seen. Serial sections disclose a completely organized thrombus which is attached throughout its entire circumference at one point but lies free in the vein at other points. No intima is present in the section, showing the complete attachment of the thrombus, but it is well preserved in the sections in which the thrombus lies free in the lumen of the vein. The media contains many hæmorrhagic areas. It is very fibrotic and contains some small round cells. The elastic tissue of the media is diminished in quantity, and the fibers are fine and fragmented especially where the groups of red blood cells are present. Areas of red blood cell accumulation are also present in the adventitia, along with an occasional small round cell and polymorphonuclear leucocyte. The hæmorrhage in the adventitia of the last case appears to be the result of trauma incident to the removal of the vein.

A microscopic study of the veins in which extravascular injections were made confirm the gross findings. The sodium chloride vein presents a diffuse hæmorrhagic reaction with absence of the intima, a well formed clot in the lumen, infiltration of all of the layers with red blood cells and leucocytes in abundance, and marked fragmentation of the elastic fibers of the media. The glucose vein has a small accumulation of red blood cells and leucocytes in the lumen, an almost normal appearing intima, a slightly cloudy media with elastic tissue fibers well distributed throughout, and an adventitia containing accumulations of leucocytes and small round cells loosely distributed

Fig. 4. Portion of cross section of vein of dog, 17 days after injection with 50 per cent glucose. Elastic tissue and van Gieson stain ×110.

about hæmorrhagic areas. There is a mass of granulation tissue about the latter vein in contrast to the acute hæmorrhagic inflammatory process about the former.

These findings are in agreement with those of Ruheman, who saw better results from the injection of 20 per cent sodium chloride than from the injection of hypertonic glucose solution. Douthwaite, too, says that his experience with glucose has been, on the whole, disappointing, but occasionally astoundingly good results have been obtained. Sir Sidney Alexander objects to the massive doses of glucose necessary to produce effective thrombosis. David Levi has felt that the looseness of the clot obtained in his studies after injecting 66 per cent glucose was contributory to the embolus resulting in one of his cases. Goldsmith, in response to Levi, states that he prefers glucose solution, since it is painless, non-toxic, does not produce local necrosis, and can be sterilized by boiling for half an hour without the production of toxic substances. Forestier (2), also in response to Levi, says that at present it is an open question whether there is any difference between the thrombus produced by glucose and that produced by the other solutions. He is further credited with saying "the only fatal cases reported in the literature followed the use of glucose." The last statement is probably incorrectly attributed to Forestier, since in his last article (3), he mentions the two cases cited in the literature in which death occurred from embolism, namely: that of Olson, who used calorose and salt solution, and that of Lomholt, who used a concentrated solution of sodium chloride. Meisen had two cases of small infarcts of the lung occur in his practice in connection with the treatment. At that time, he was using concentrated sodium chloride, but attributed the accidents to the use of 25 cubic centimeters of the solution. He refers to 25 cubic centimeters as an "infarct giving dosis." He has since changed his solution to sodium salicylate 25 per cent and sodium chloride 10 per cent, equal parts, and he limits the amount injected to 10 cubic centimeters. He adds: "It is noteworthy that these cases of phlebitis and with infarction all had a very marked dilatation of the main trunk of the femur."

Our results confirm the statement that under ordinary circumstances glucose does not produce necrosis but is less reliable as a sclerosing agent than concentrated sodium chloride. The thrombus obtained from glucose injection certainly was firmly attached to the entire circumference of the vein as may be observed from Figure 4. It will probably prove to be a very valuable sclerosing agent in the thin veins of women with rather adipose legs, where, from our present experience, we feel that sodium chloride injections are accompanied by the hazards of periphlebitis and sloughing. It may also prove of advantage in cases of advanced years where cardiac irregularity and arteriosclerosis is a factor.

Meisen has recently added a few interesting contributions to the technique of the treatment. In cases in which the main trunk of the femur is injected, he compresses the trunk at intervals by a pelotte held in place by a circular band of adhesive tape tightened down to 1 centimeter below the skin level. As a rule, the phlebitis and thrombosis do not extend above the adhesive tape. However, once in a great while it extends above the bandage, the strips of which leave deep impressions in the thrombus and thus anchor it. In delicate telangiec-

tases, which the patients wanted removed for cosmetic reasons, he slit open the venules in two cases with a cataract knife and covered the wound with a compress, moistened with the injection fluid. He prefers to insert the cannula in the vein with the patient standing with his weight on the limb whose veins are to be injected. He has found that the placing of the body weight on that leg increased the venous pressure in its varicose veins on an average of from 6 to 10 centimeters of water. The veins then stand out more clearly and are more easily entered, after which the patient is allowed to lie down and the injection is made. We have utilized the latter principle by having our patients sit astride a dressing-room table with the leg to be injected on a stool and the patient bearing heavily on that leg. The application of hot towels to the limb for a few minutes will often make the veins become more prominent. After the needle is inserted into the vein, the patient may be changed to the horizontal position and the leg either elevated or kept on the level with the rest of the body without disturbing the position of the needle. Like Dunbar and others, we have preferred to direct the point of the needle downward and start the series of injections as low down as possible. Compression is made over the site of injection by a pledget of gauze for about 3 or 4 hours. We have felt that this procedure prolongs the contact of the solution with the intima of the vein and insures a better reaction and to a greater degree limits the upward extent of the thrombus. Sicard has demonstrated, by lipiodol injections into veins, the passage of lipiodol into the deep veins on slight muscular movement. If there has been no deep thrombophlebitis, and the injection fluid enters the normal veins, Meisen believes that it is washed away by the circulating blood. Such is probably the case, since practically no reference is made in the literature to deep thrombophlebitis as a complication of the treatment. One of our patients did complain of pain deep in the posterior portion of the thigh for a week following an injection into a vein on the anterior surface of the thigh. However, there was no œdema and local findings were so questionable that the diagnosis of deep thrombosis was doubtful.

SUMMARY

In experimental studies conducted on dogs with 20 per cent sodium chloride and 50 per cent glucose as sclerosing solutions for the obliteration of veins, we found the sodium chloride solution to be more effective than glucose but more irritating when injected extravascularly. There was apparently no difference in the structure of the thrombi or their adherence to the wall of the vein, although only one thrombus was obtained following glucose injection, whereas, thrombi developed uniformly following sodium chloride injection. When the irritative process extended through the entire thickness of the wall of the vein, the elastic tissue of the media was especially liable to destruction. The effect on the elastic tissue was more marked in the veins injected with sodium chloride than in those injected with glucose.

The clinical technique and complications are discussed. A case of auricular flutter developing after the injection of 10 cubic centimeters of 20 per cent sodium chloride is reported.

After a comparison of the results obtained by operation with those obtained by the injection of sodium chloride solution in the treatment of varicose veins in men, we feel that the injection treatment offers many advantages over operative treatment and yields as good if not better results than those obtained by operation. Our results from the use of sodium chloride in women have not been as satisfactory as those in men.

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THE PATHWAY FOR VISCERAL AFFERENT IMPULSES WITHIN THE SPINAL CORD

II. Experimental Dilatation of the Biliary Ducts[1]

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SOME years ago one of us (2) became interested in an attempt to determine the pathway for visceral afferent impulses within the spinal cord. In those experiments vasomotor, respiratory, and other evidences of pain were produced by faradic stimulation of the thoracic-sympathetic trunk in cats. Various horizontal lesions were produced in the spinal cord in an effort to obliterate these responses. It was found that a transverse section of the cord was the only experimental lesion which would be followed by a cessation of the responses to stimulation. It was concluded that painful impulses from the viscera, transmitted by the thoracic-sympathetic trunk, are conducted upward by relays of short spinal paths with synapses in the gray matter of the spinal cord. These results were different from those of Ranson, von Hess, and Billingsley (8, 9) who traced the pathway for somatic afferent impulses which were accompanied by similar vasomotor and respiratory effects. They stated that these impulses enter the spinal cord through the lateral division of the dorsal roots, which consists of unmyelinated fibers, and ascend in the tract of Lissauer near the apex of the posterior horn.

In addition to its academic importance, the knowledge of the location of the visceral afferent pathways within the spinal cord and of the manner in which they reach the spinal cord is of clinical interest. Stookey has presented clinical evidence which supports the view that this pathway is situated in a juxtagriseal position. He pointed out that, in extradural spinal cord tumors, bladder and rectal disturbances are not present until compression of the cord is extreme. Schrager and Ivy have shown that dilatation of the cystic duct in the dog is accompanied by a marked inhibition of respiration, vomiting, struggling, and other evidences of pain. These responses could be abolished completely by section of the right splanchnic nerve. Spiegel and Bernis found that the reactions which occurred after stimulation of the right splanchnic nerve were abolished only after destruction of the anterolateral columns of white matter in the spinal cord. This would indicate a similar intraspinal course for visceral afferent impulses and those of pain and temperature sensation. However, the illustrations of their experimental lesions show an extensive destruction of the gray matter. Kappis and Neumann have stated that the viscera receive their sensory innervation in a segmental manner from the right and left splanchnic nerves. Laewen relieved patients with visceral pain by the injection of 2 per cent novocain solution into the lateral vertebral foramina. He obtained successful results, which were of course brief, but von Gasa and Leriche used the same procedure as a preliminary therapeutic step. After they determined the level at which the pain could be relieved they sectioned the rami communicantes and simultaneously removed the posterior root ganglia. Since then Scrimger and Archibald have reported successful results after a similar procedure.

For many years surgeons have attempted rather empirically to relieve the pain of the gastric crises of tabes by posterior root sections and by anterolateral sections of the spinal cord, first suggested by Spiller and carried out by Martin. These operations have been followed by indifferent results. One of us recently has had a clinical experience in point. The posterior and anterior roots from the fourth dorsal to the twelfth dorsal were sectioned bilaterally in a patient with severe visceral crises. This procedure was carried out in two operations and inadvertently the eighth pair of spinal roots were left intact. Although the area of superficial cutaneous sensibility represented by this root was extremely small, the patient continued to have

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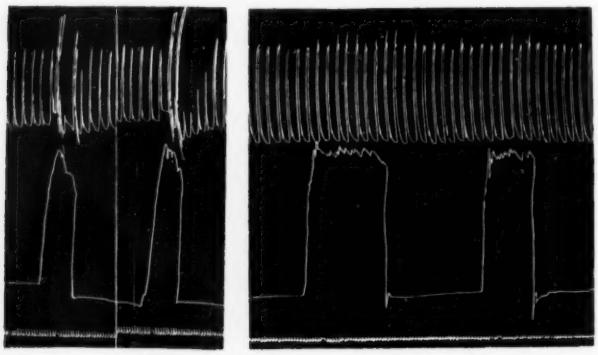

Fig. 1. A (left), Tracing upon normal animal. The upper tracing is of the respirations and shows an inhibition which occurs at the height of the lower tracing which is the water pressure used expressed in millimeters of mercury. B, Same animal, Dog 10, after the right splanchnic nerve was cut showing the absence of inhibition of the respirations.

the crises unabated. It would appear that only a very small pathway to the spinal cord was sufficient to carry the impulses from this patient's visceral crises.

In the present experimental work we have concerned ourselves with a study of the spinal cord pathway for visceral pain initiated by the forceful dilatation of the cystic duct and biliary passages.

EXPERIMENTS

All of our experimental work was done upon dogs. We used 75 animals upon all of which an autopsy was performed. Each step in the problem was repeated several times because different dogs did not always react to the same stimuli in the same way, and allowance must be made for this fact. Our experiments may be said to fall into two groups: (a) those in which attention was directed to the right splanchnic nerve and (b) those in which attention was centered upon the spinal cord.

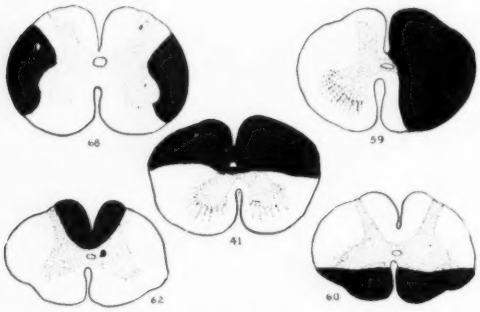

Fig. 2. A diagram showing the various types of spinal cord lesions produced experimentally.

The former group of experiments consisted essentially of a repetition and verification of some of the evidence already shown by Schrager and Ivy. Our procedure in this group of experiments was as follows: The animal was prepared and anæsthetized in the usual manner under strict aseptic technique, the abdomen was opened through a right rectus incision, and a small glass cannula was inserted into the cystic duct through the gall bladder and ligated in place with linen. The common bile duct was then ligated just proximal to its duodenal junction and the abdomen was closed. The animal was allowed to recover from the anæsthetic and 24 hours later was prepared for a kymographic tracing. Sterile water at 39 degrees C. was injected into the cannula tube and the reaction was noted. This always caused the dog to struggle and show other signs of discomfort; there was also marked inhibition of respiration at the beginning of the injection, and, frequently, the animal became salivated (nauseated) and vomited, especially if the pressure exerted was above 150 millimeters of mercury.

After the demonstration of the reaction described, the animal was again anæsthetized

Fig. 3.

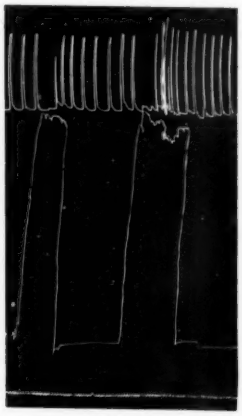

Fig. 4.

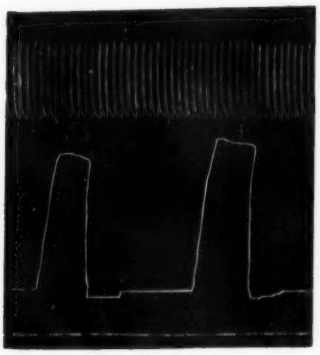

Fig. 5.

Fig. 3. Tracing of an animal with a lateral hemisection of spinal cord, Dog 59. Compare with section 59, shown in Figure 2.

Fig. 4. Tracing of an animal with a posterior section of the spinal cord, Dog 62. Note the absence of inhibition of respirations. Compare with section 62, shown in Figure 2.

Fig. 5. Tracing of an animal with a posterior hemisection showing the absence of inhibition of respirations, Dog 41. Compare with section 41, Figure 2.

and the right splanchnic nerve was exposed through a right lumbar incision. A segment approximately 1 centimeter long was removed from the nerve. The wound was sutured and the animal was allowed to recover for a period of 24 hours. Then the kymographic tracing was repeated, the same procedure as before being followed, and the results noted. In no instance was there any evidence of pain or distress upon dilatation of the ducts. There was a partial diminution of respiratory inhibition, but salivation and vomiting were observed as frequently as before the nerve was severed. These findings agree with the results obtained by Schrager and Ivy, who showed that cutting the right splanchnic nerve abolishes all pain dependent upon dilatation of the cystic and biliary passages.

B. Experiments Centered upon the Spinal Cord

Inasmuch as we intended to interrupt, if possible, the spinal cord pathway of fibers from the right splanchnic nerve, it was admittedly necessary to produce the cord lesion above the known exit of its fibers. The nerve arises from the sixth, seventh, eighth, ninth, and sometimes the fifth and tenth thoracic segments. We, therefore, arbitrarily chose the second or third thoracic segment as the level at which all lesions would be made. Each animal was prepared and anæsthetized in the usual manner, and the strictest aseptic pre-

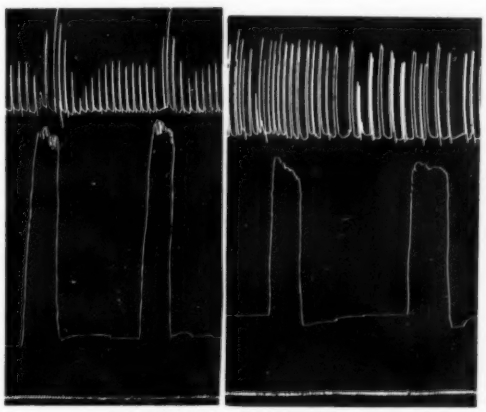

Fig. 6 (left). Tracing of an animal with an anterior section of the spinal cord showing inhibition of respirations, Dog 60. Compare with section 60, Figure 2.

Fig. 7. Tracing of a dog with bilateral anterolateral section of the spinal cord showing inhibition of respirations, Dog 68. Compare with section 68, Figure 2.

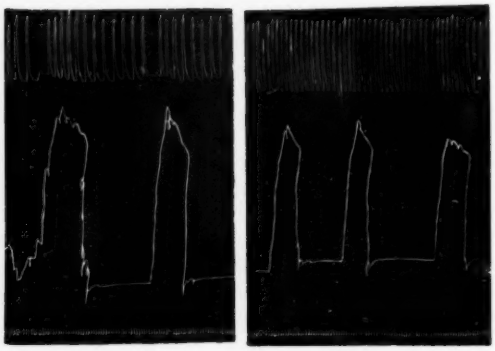

Fig. 8. A (left), Tracing of Dog 48 showing inhibition of respirations upon dilatation of the cystic duct; B, same animal after complete transverse section of the spinal cord showing absence of inhibition of respirations.

cautions were taken. The spines of the upper three or four thoracic vertebræ were exposed and enough of the laminæ removed to expose the cord for a distance of 3 centimeters. The dura was incised and the desired lesion made in the cord, a Frazier chordotomy knife or a fine cataract blade being used. The muscles and fascia were sutured with plain catgut. The skin was closed with dermal sutures, and the animal was allowed to recover.

At least two weeks were allowed to elapse before the second operation in order to allow for degeneration of the cut fibers in the cord. By that time sufficient degeneration had taken place in columns affected by the lesion to show as such with the Marchi stain, and most of our cords were stained by this method. The animal was then prepared for the second operation. With aseptic technique the abdomen was opened and a small cannula placed in the cystic duct through the gall bladder and ligated in place with linen. The common bile duct was then ligated just proximal to its duodenal junction and the abdomen was closed. When the animal had recovered from the anæsthetic or later (4 to 24 hours), he was prepared for a kymographic tracing. Sterile water at 39 degrees C. was then injected into the cannula tube and the reaction noted. If the dog struggled, cried out, or showed any distress whatever, other than slight respiratory inhibition, it was assumed he was in pain.

After the reaction had been recorded on the tracing, the animal was prepared for autopsy and the spinal cord removed. Small segments at the level of the lesion as well as above and below were removed for Marchi staining.

This procedure, step by step, was repeated many times and various lesions were made in the spinal cord such as right and left hemisections, posterior and anterior sections, posterior hemisection, and bilateral anterolateral sections. The cystic ducts of normal dogs were cannulated, the ducts dilated, and the reaction noted, and the same procedure was repeated upon the animals after a complete transverse section of the cord. In other animals the same procedure was carried out, but instead of cutting the cord, the dorsal roots of all the thoracic nerves were severed intradurally and the reaction noted upon dilatation of the cystic and biliary ducts.

Our observations may be briefly summarized as follows: Dilatation of the cystic and biliary ducts in dogs causes pain, inhibition of respiration, and frequently nausea and vomiting. Dilatation of these ducts after the cutting of the right splanchnic nerve abolishes the evidences of pain and diminishes the respiratory inhibition. It does not appreciably affect the frequency of nausea and vomiting. Lateral hemisections of the spinal cord at the level of the second or third thoracic segment have no effect upon the responses which accompany bile duct dilatation, nor do posterior sections at the same level which destroy practically all of the cuneate and gracilis columns without extensive damage to the central gray matter. Posterior hemisections, which destroy not only the posterior horns but also a portion of the central gray matter, abolish these responses. Anterior sections which involve only the white matter or anterolateral sections limited to the white matter have no effect upon the responses. Complete transverse section of the cord at the level of the third thoracic segment abolishes all responses as does intradural rhizotomy of all of the thoracic posterior roots.

DISCUSSION

This evidence is corroborative of Davis' experiments in which an artificial stimulation

was used to simulate visceral afferent impulses. We feel that these experiments are as close an analogy as is possible to the mechanism of pain from the biliary tract in a patient. Secondarily, we are able to offer corroboration of the experiments of Schrager and Ivy who traced the pathway through the right splanchnic nerve to the spinal cord.

However, we believe that the most practical suggestion which may result from this work concerns the operative procedures which may be aimed at the spinal cord for the relief of visceral pain. From our work it would appear illogical to perform anterolateral sections of the spinal cord for the relief of gastric crises unless the sections include a considerable destruction of the gray matter. This is quite in keeping with the indifferent results obtained after this operation for the relief of gastric crises and gives an explanation for those cases in which relief was obtained by a section which was deeper than usual.

It would appear that posterior root sections should produce relief in patients with visceral pain. From our clinical experience as well as from our experimental evidence, it seems obvious that a much larger number of roots than is common must be sectioned. The short course of these fibers within the cord and their innumerable synapses and relays make it difficult to remove all of the pathways for the visceral afferent impulses without a rather extensive rhizotomy.

It must be remembered that these experiments in no way question the pathway for the transmission of pain of somatic origin within the spinal cord. For such conditions anterolateral chordotomy is an operation which will yield definite relief.

CONCLUSIONS

1. Afferent impulses which result from the forceful dilatation of the cystic and biliary ducts travel toward the spinal cord in the right splanchnic nerve.

2. Section of a sufficient number of thoracic posterior spinal roots will abolish all of the responses obtained by forceful dilatation of the biliary ducts.

3. The only lesions of the spinal cord, other than complete transverse section, which abolish these responses are those which involve a considerable portion of the central gray matter of the spinal cord.

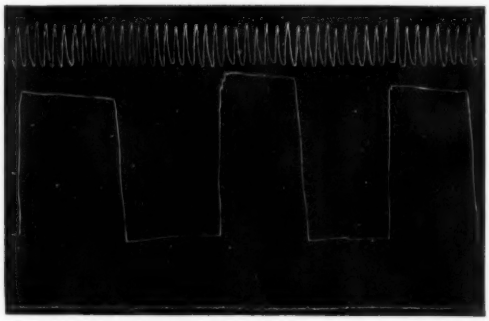

Fig. 9. Tracing of Dog 74 showing absence of inhibition of respirations after a bilateral posterior root section in the thoracic segments of the spinal cord.

4. Visceral afferent impulses are transmitted upward within the spinal cord by short fibers with many relays and synapses which have a juxtragriseal position.

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STAB WOUNDS OF THE SPINAL CORD

Report of Seven Cases

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STAB wounds of the spinal cord are of sufficient rarity to merit recording. Only seven instances have been observed at the Los Angeles General Hospital, since March 15, 1923, in a series of over one hundred and seven thousand cases. The interest of one of us (C. W. R.) was first drawn to the subject in the summer of 1915 when a policeman, suffering from a recent stab wound of the cord, was admitted to a large Chicago Hospital. The injury had been sustained but a few minutes before admission and was occasioned by his being stabbed in the back with an ice pick. The external wound was merely a small puncture which would almost escape casual observation. However, he showed evidence of complete interruption of the spinal cord at the level of the injury which was in the upper thoracic region. In a few weeks the picture changed from one of complete cord lesion to that of a typical Brown-Séquard type and then remained stationary. During his stay in the hospital, many discussions were held as to the advisability of exploring the cord. This was finally deemed inexpedient. An attempt to secure the original record has been unsuccessful and the case can only be referred to in passing.

The rarity of the condition was recognized at the time, and since then has been more impressed upon us. It is difficult to produce manually because of the exceptional bony protection which nature has placed about the cord. Severe back injuries accompanied by spinal cord injury are common and constantly increasing in number. Automobile accidents, injuries incurred in the building trades, and gunshot wounds account for the great majority. These will not be considered, however, as the mechanism of their production is essentially different from that of a true stab wound of the spinal cord.

One is impressed by the fact that the large majority of stab wound cases have been reported by French and German observers and that very few are reported by English or American writers. The latter half of the 19th century reveals the greatest number of reported cases. One is again reminded that in conjunction with animal experimentation, much knowledge of the conduction pathways of the spinal cord has been gained in the past from a correlation of the physical findings with postmortem studies of the spinal cord in victims of stabbing frays. One reads again of the controversy which was waged, a generation or more ago, on the question of regeneration of "the spinal cord marrow."

In the great majority of stabbing cases, the injury to the spinal cord is purely accidental. One could almost never deliberately pierce a spinal cord with a sharp instrument. The majority of cases are the results of fights or brawls, in which the blow is dealt haphazard being usually aimed at the throat, neck, or chest. A sharp pointed instrument is the rule, most commonly a knife. Other implements, however, have been recorded, such as a dagger, stiletto, sword, saber, sickle, file, awl, razor, shoemaker's knife, gimlet, hat pin, ice pick, bayonet, etc. The blow is usually struck with a full swing of the hand and arm. It is accompanied by little, if any, pain. Several of the patients who have been under observation have been questioned with this point in view and all have remarked that "it didn't hurt." They knew they had been knocked down and immediately found that they could not get up again and walk. Sometimes one leg was paralyzed and numb, but more often both were involved, depending upon the extent of cord damage. Eve reports a case in 1851, in which a Drummer of the National Guards of Paris threw his sword at a comrade, stabbing him in the back of the neck—thus causing immediate paralysis of the right arm and leg, with preservation of function of the left. Doubtless others have suffered similar lesions as a result of being struck by some hand-thrown weapon. The days of the broad sword and lance could doubtless

have furnished many examples of penetrating wounds of the spinal cord, were records available. Gribbon reports a case of attempted suicide in a man who inflicted a puncture wound in the nape of his own neck. It is stated that the membranes of the cord were ruptured, resulting in a cerebrospinal fluid leak, and the patient succumbed, on the eighteenth day, from meningitis. The right hand, presumably the one with which he struck, "went numb" immediately after the blow. That a cerebrospinal fluid leak may not follow immediately is shown by Vorster's case, in which it appeared on the eighth day and closed on the sixteenth day following injury.

The majority of wounds are in the cervical or upper thoracic regions. This is partly due to the fact that these regions come within the natural sweep of the arm, and partly because the blow is aimed at the neck or chest. Wagner and Stolper in their admirable collection of 81 cases from the literature found 39 to be cervical and 42 upper thoracic; and Petrén's table of 93 cases, which includes some of the former, found 43 cervical and 50 thoracic. Of the thoracic cases, only 11 were struck below the sixth dorsal vertebra. The blow may fall at the base of the skull and penetrate the spinal canal between the occiput and the atlas. Staub and Weiss report such cases, the cervical cord being severed or hemisected and the result being fatal. Ruehl's case did not die and Hofmann's was followed by immediate paralysis which later cleared up. He concluded that in all probability the paralysis was due to hæmorrhage into the canal and that the cord was not cut. Courtin reports a fatal case in which the stab wound went through the arch of the atlas; and another instance of penetration of the canal, in which, in a negro encounter, a deep gash wound was inflicted by means of a razor. The point of the knife may not infrequently become broken off and left in the canal, or wedged into the surrounding bony structures. Cuvillier, Vogt, W. Mueller, Charcot, Owen, and Eve mention such cases. Rodrigues reports an instance in which the broken fragment pierced the canal and remained there for 28 years. Death finally occurred from nephritis. Autopsy showed a

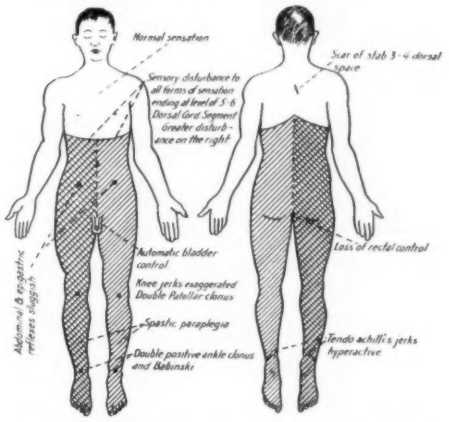
Normal sensation
Sensory disturbance to all forms of sensation ending at level of 5-6 Dorsal Cord Segment Greater disturbance on the right
Scar of stab 3-4 dorsal space
Automatic bladder control
Knee jerks exaggerated Double Patellar clonus
Spastic paraplegia
Double positive ankle clonus and Babinski
Abdominal & epigastric reflexes sluggish
Loss of rectal control
Tendo achilli's jerks hyperactive

Fig. 1. Case 2. Diagrammatic chart showing condition of patient before operation.

rusty file disintegrated and almost dividing the lumen of the canal into two openings.

That the spinal cord is unusually well protected goes without saying; indeed, it is difficult to believe that a stabbing fray could result in having the weapon penetrate the canal. Frazier has remarked that the blow is most often downward, which would facilitate entering between the spines or the spaces between the laminæ. It would seem to us that the blow is more often directly horizontal, or a little upward in direction. It may be glancing and injure the cord on the side opposite the puncture wound in the skin. In certain instances the weapon may penetrate the intraspinous spaces cleanly, pierce the ligamentum subflavum, and enter the canal without inflicting any bony damage. More often some of the bony structures are struck, and not infrequently the direction of the spines and laminæ may act as a guide, directing the course of the blade. In two of our cases the spinous processes have been fractured, and in a third, indriven fragments were found in the canal. Such indriven fragments may cause enough pressure to give symptoms of a cord lesion.

Any type of injury may occur to the cord itself. Not infrequently it is completely severed, although this is far from the rule. More often it is partially cut or hemisected, giving rise to the Brown-Séquard picture so often described. There may be penetration of the dura

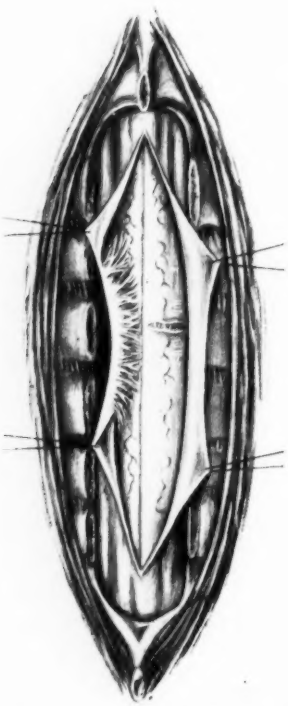

Fig. 2. Case 2. Sketch showing operative findings. The adhesions on the left, together with a large portion of dura here shown, were removed. Dense scar tissue present in stab wound.

without damage to the cord itself, as probably occurred in Cuvillier's case, a soldier who was stabbed at the twelfth dorsal vertebra, and thereafter walked some 80 miles. The point of the knife was broken off in the canal. Again the cord may be irreparably damaged, even when the dura is not penetrated. Intramedullary hæmorrhage probably occurs in the majority of cases in which the cord has been penetrated. It is associated with œdema. Hæmorrhage into the canal is usually present, and may be large enough to cause pressure symptoms, leaving after its absorption adhesions and thickening of the surrounding envelopes. Degenerative changes in the cord always follow penetrating wounds, the type, direction, and degree of degeneration depending upon the tracts injured. It is not necessary to discuss the possibility of regenerative cord changes, a subject which was warmly discussed in cases of cord injury a generation ago. Would that regeneration might occur! Œdema always takes place to some extent, and may account for the fact that the initial symptoms following a stab wound of the cord are more extensive immediately following the injury than later on. Acute swelling prohibits the function of intact fiber tracts which may recover as œdema subsides. It was perhaps this fact that gave fuel to the heated discussion of the degree of recoverability of an injured cord. After a period of time gliosis and fibrous changes set in and decided thickening of the surrounding membranes follows. In our second case such changes were found 5 months after the injury. Cerebrospinal fluid leaks have been mentioned and are to be feared. That they are not more common is due to the fact that the inflicting instrument is narrow, and the muscles contract after the weapon is withdrawn, thus effectually closing the tract. Infection, however, may follow such a leak, or, even in its absence, may give rise to meningitis.

Symptoms of paralysis occur immediately after the injury if the cord is penetrated. They may be delayed in cases of simple hæmorrhage into the canal. Little or no pain is experienced in the majority of cases, an argument against the so called sensibility of the dura. In none of the cases we have observed has pain been experienced. Root pains, however, may be seen, and cases have been mentioned associated with sharp pain encircling the chest, abdomen, or radiating to an extremity. Tearing pains in the legs have been mentioned. There may be local tenderness of the soft tissue at the site of injury, and crepitus of a broken spine on occasion may be felt. The symptoms of sensory and motor paralysis vary according to the level and extent of the cord damage. The majority of cases resolve themselves into the mixed or Brown-Séquard type. We have seen a flaccid paralysis of the extremity change to a spastic condition, in a short time, and later clear up. Bladder symptoms are common: often retention at first, later passing over to an incontinent or automatic type of bladder control. It is our impression

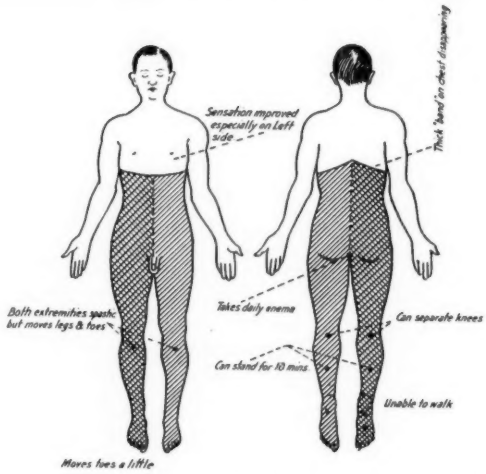
Sensation improved especially on Left side
Thick band on chest disappearing
Both extremities spastic but moves legs & toes
Takes daily enema
Can separate knees
Can stand for 10 mins.
Unable to walk
Moves toes a little

Fig. 3. Case 2. Diagrammatic chart of findings 3 months after operation.

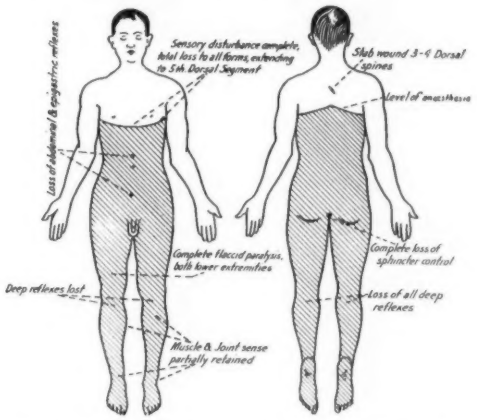
Loss of abdominal & epigastric reflexes
Sensory disturbance complete, total loss to all forms, extending to 5th Dorsal Segment
Stab wound 3-4 Dorsal spines
Level of anaesthesia
Complete Flaccid paralysis, both lower extremities
Complete loss of sphincter control
Deep reflexes lost
Loss of all deep reflexes
Muscle & Joint sense partially retained

Fig. 4. Case 4. Diagrammatic chart of findings before operation.

that the majority of cases become ambulatory with more or less residual symptoms, depending on the severity of the cord injury.

There is a relatively low initial mortality. Probably meningitis is the principal cause of death, although general marasmus, decubitus, and genito-urinary infections are factors to be considered in all cases. Thorburn reported 40 cases with 15 deaths, 9 of which were due to meningitis. The mortality is greater in the cases of high cord lesions and decreases as one goes down the canal. Roesler reported 46 cases, with a cervical mortality of 40 per cent and a thoracic mortality of 31 per cent. Mortality in stab wounds between the first and second cervical was 71 per cent; at the fourth, 53 per cent; and at the fifth, sixth, and seventh levels, 23 per cent. Frazier has combined the mortality of the series of Wagner and Stolper and of Enderlen, comprising 148 cases with the following results:—

	Cases
Wagner and Stolper	81
Enderlen	67
Total	148

	Per cent
Complete recovery	14
Permanent improvement	65
Death	21

We believe that all cases of stab wound of the cord do not demand operation. One must be guided by the patient's condition, the level of the lesion, the degree of apparent cord damage, the presence or absence of a cerebrospinal leak, etc. Roentgenograms should be made in all cases to ascertain whether or not a foreign body has been broken off, as well as to determine whether there has been bony injury to the spines or laminæ. Small fragments of bone may be driven into the canal and not show in a roentgenogram. We have had this experience in one case. However, fractures or large indriven fragments should be seen. We believe a lumbar puncture should be done in all cases to determine the amount of free blood which may be present in the subdural space. Queckenstedt's procedure will give evidence as to the presence or absence of a spinal block. The wound should not be probed and should be treated aseptically. If laminectomy is not done, we believe the stab wound should be closed. Any indriven bone fragments, or broken pieces of metal, should be removed. Subdural hæmorrhages should be relieved. Cerebrospinal leak usually calls for exploratory laminectomy. We believe that opening the dura in the majority of cases relieves œdema to a certain extent and adds to the degree of recoverability of the cord. There are certain late cases, in which improvement has come to a standstill, that can be helped by removal of

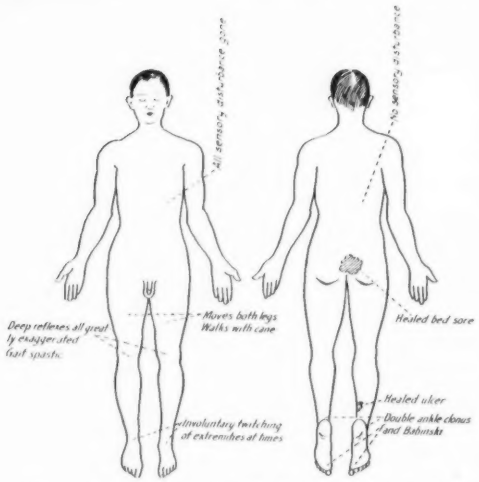

Fig. 5. Case 4. Diagrammatic chart of findings 3 months after operation. The sensory symptoms practically disappeared, but patient was still spastic.

thickened membranes and scar tissue about the cord at site of injury. Pathology of this type, to some extent, complicates every case. All cases demand careful nursing, with strict attention to the bladder, and rigid precaution that decubitus or contractures do not develop.

Case 1. Stab wound in the left back about level of fourth dorsal vertebra. Immediate paralysis of the left leg and sensory changes on the right side of body ending at the level of the sixth dorsal cord segment. Recovery in 2 weeks.

J. A., male, aged 32 years, married, Spaniard, cook, No. 187,170, was admitted to the Los Angeles General Hospital, March 15, 1923, complaining of paralysis of the left leg. Earlier that night he had been stabbed in the back by his business partner. His left leg immediately became paralyzed.

On admission to the hospital, a stab wound was found in the left side of the back. The laceration was about 2 inches long and lay just at the inner border of the scapula, some 3 inches above the angle. No cerebrospinal fluid leak was present, but the wound became infected, and drained 10 days. The general physical examination was negative. The left leg was described as helpless and very spastic. One could flex the knee. The right leg was normal so far as muscular power went. There was a definite Brown-Séquard type of sensory disturbance, the right lower extremity and the right side of the trunk being hypæsthetic to all forms of sensation. There was a fairly definite upper level of sensory change ending at approximately the sixth dorsal segment. The deep reflexes of the left lower extremity were not especially exaggerated. The sphincters were not disturbed. No trophic changes developed. On the following day the patient could move the left leg, and the sensory changes on the right side were less marked. Within 10 days he was walking about, and he eloped from the hospital on the evening of March 29, 1923, 2 weeks after the injury. We have been unable to get in touch with him since.

Case 2. Stab wound between spines of fourth and fifth dorsal vertebræ. Symptoms of complete cord lesion at level of sixth dorsal cord segment, immediately following injury; right hemisection of cord, thickening of dura, and indriven bone fragments found at operation 3 months later. Improvement.

F. V., male, Mexican, farmer, aged 33 years, married, was referred by Dr. Charles Lewis Allen and Dr. J. A. Gaxiola of Los Angeles, on August 5, 1923. Fifty-two days previously he had been stabbed in the back with a knife. The stab was more in the right side, just at the level of the fourth dorsal vertebra. He was immediately paralyzed, and apparently there was a complete anæsthesia and loss of all reflexes, superficial and deep, below the level of the lesion. He also had loss of bladder and rectal control. After 8 days there was some improvement in the latter, and by the end of a month he could control his bladder and bowels. He became very spastic in both lower extremities, which remained completely paralyzed.

Examination on August 15, 1923, revealed a well built man, in good general condition. In the upper dorsal region about the level of the fourth vertebra, one found a scar about 2 inches in length and passing diagonally between the spines of the fourth and fifth vertebræ; it was practically midline, a little more to the right than the left.

Spinal cord examination: Patient was paraplegic, being able to flex the right knee very slightly. There was very marked spasticity of the lower extremities, with strong adduction spasm. There was disturbance of all forms of sensation: touch, heat, cold, pain, vibratory, muscle and joint sense extending to the level of the sixth dorsal cord segment. The sensory disturbances were more marked on the right side than on the left. In places the disturbances were patchy but ended at a level corresponding closely to the fifth and sixth dorsal cord segments. Abdominal and epigastric reflexes were present, although the latter were very sluggish. Biceps jerks were present and equal. Triceps jerks were not obtained, right or left. Radial jerks were present and equal. Knee and Achilles tendon jerks were very active, the patient being thrown into a patellar and ankle clonus when these reflexes were tested. The patient had automatic control of the bladder, but did not control the bowels (Fig. 1). No trophic ulcers had appeared anywhere. X-rays of the spine did not reveal any bony pathology.

A laminectomy was carried out on September 6, 1923, the spines of the second, third, and fourth dorsal vertebræ being removed. Dense scar tissue was encountered through all layers of soft tissue and

muscles between the fourth and fifth dorsal vertebræ. There was much bone oozing. The dura was much thickened and very vascular. Two indriven pieces of bone were removed from the dura, and scar tissue surrounded the spinal cord. The cord was uncovered 1 centimeter above and 3 centimeters below the point of the greatest damage. At this point the dura was densely adherent to the cord, and this structure was bound down by scar tissue. The dura was freed behind and cut away. No attempt was made to free it in front of the cord. The point where the knife blade had entered the cord was identified and revealed practically a right hemisection (Fig. 2). Scar tissue was removed from the left side of the cord, thus allowing it to expand. No attempt was made to close the dura.

There was some improvement in sensation by the tenth day following operation. At that time he could move the right foot and leg a little and was experiencing involuntary muscle jerking on this side. Sensation over the left leg had improved appreciably but not in the right.

A letter received from him some 3 months after operation stated: "Every day I feel more sensibility in my legs, especially the left. I can move my legs and toes a little, and can separate my knees and draw them together. My legs are not hard as before. I can remain standing 10 minutes at a time, but when I wish to walk, my legs draw up and I cannot extend them. The thick dead band I used to feel on the chest and abdomen has been disappearing, and each day I feel more sensibility in the right side. Must have an enema every day, otherwise there is no movement of the bowels. I feel it perfectly when it is taking place." (Fig. 3.)

Case 3. Stab wound between bodies of fifth and sixth dorsal vertebræ, penetrating dura. Marked hæmorrhage into spinal canal. Hæmothorax on right side of chest from second stab wound. Death.

O. M., female, aged 23 years, married, colored, No. 229,952, was admitted to the Los Angeles General Hospital on June 9, 1925, in a critical condition. She had been stabbed twice by her husband, a few hours before admission. Two stab wounds were noted; the first, about 1 inch to the right of the fourth dorsal vertebra, took a downward direction, and the second was in the third intercostal space on the right side in the mammary line. She was almost exsanguinated and in severe shock. A diagnosis of right pneumothorax was made. There was no note of motor or sensory disturbances referable to a cord lesion. The patella reflexes were normal. On June 16, 1925, the patient became dyspnœic and presented a picture of fluid in the right chest, with displacement of heart to the left. X-rays showed no bony injury to the right chest, but the right thorax was opaque throughout, with extreme displacement of the heart to the left, the apex being at the axillary margin. This was considered consistent with fluid in the right thorax. Large amounts of blood were aspirated from the chest on several occasions, and a blood transfusion carried out on June 19, 1925. She

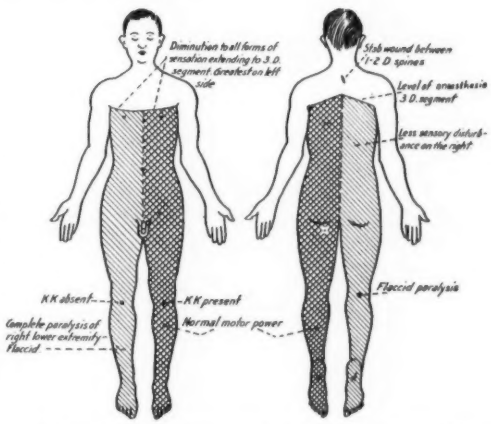
Diminution to all forms of sensation extending to 3 D. segment. Greatest on left side
Stab wound between 1-2 D. spines
Level of anæsthesia 3 D. segment
Less sensory disturbance on the right
K K absent
K K present
Complete paralysis of right lower extremity—Flaccid
Normal motor power
Flaccid paralysis

Fig. 6. Case 6. Diagrammatic chart of findings before operation.

remained dyspnœic and died on June 23, 1925, two weeks after admission. It is doubtful whether it was appreciated during her stay in the hospital that the spinal canal had been entered. The coroner's report, however, described the spinal cord lesion to which death was attributed and did not discuss the hæmothorax.

Coroner's report. I found a stab wound located 3.25 inches below the shoulder level in the median line of the back. Its course was downward and to the right for 3 inches; then having passed between the fifth and sixth dorsal vertebræ, it had pierced the coverings of the spinal cord. There was marked hæmorrhage into the spinal canal and along the spinal cord. The width of the wound at entrance was three-eighths of an inch. Death was due to a stab wound of the spinal cord.

Case 4. Stab wound between third and fourth thoracic spines, spinal cord pierced to left of midline but not severed. Complete cord lesion at level of fifth thoracic cord segment following injury. Exploration; gradual improvement so that patient was ambulatory 18 months later.

A. W., aged 21 years, single, laborer, No. 229,617, was admitted to the Los Angeles General Hospital on June 4, 1925. About 11:30 the previous evening he was held up and robbed. Following the robbery he ran after his assailants and was stabbed in the back and right elbow. Immediately following the stab in the back his legs were completely paralyzed. Examination on June 6, 1925, revealed a young adult with a small crucial stab wound of the back, just to the left of the spinal column and at the level of the third and fourth thoracic spines. There was complete flaccid paraplegia as well as a total loss of heat, cold, pain, and touch sensation ending at the fifth dorsal cord segment. It was thought that muscle and joint sensation was in part retained. There was loss of all superficial and deep reflexes below the level of the

lesion. Bladder and rectal control were lost; priapism was present at times (Fig. 4). He had a temperature of 103 degrees a few hours after admission, dropping to 99 degrees thereafter. X-ray examination of the upper dorsal spine revealed no fractures. Blood and spinal fluid Wassermann tests were negative. It was not stated whether there was free blood in the spinal fluid.

On June 9, 1925, a laminectomy was done. Spinus processes of the second, third, and fourth vertebræ were removed. The second and third were found fractured at the base. The line of the stab wound could be followed directly into the spinal canal where it entered the dura on the left side and pierced the cord in the left dorsal column. At the point of intersection into the cord, the wound measured approximately 2 by 3 millimeters in diameter, and did not penetrate the substance of the cord more than 3 millimeters. The cord was otherwise swollen and hæmorrhagic. No free blood was found in the subdural spaces.

Following operation the patient developed a large sacral bed sore and trophic ulcers on both heels, which subsequently healed. He remained completely paraplegic until September 11, 1925, three months after his injury, when it was noticed that there was slight movement in the right lower extremity. On September 18, 1925, he was able to move both legs slightly, and by September 25, 1925 could flex both knees. From that time on his improvement was gradual, but steady, and by September 18, 1925, although very spastic, he was able to walk with the aid of a cane. Sensation for touch, pain, and temperature had entirely returned. There was bilateral ankle clonus and Babinski and at times involuntary twitching of the extremities. The deep reflexes were greatly exaggerated and about equal (Fig. 5).

Case 5. Stab wound of the back between the spines of the second and third vertebræ. Flaccid paralysis of right lower extremity, no sensory disturbances noted. Cord not explored; gradual return of power in right leg.

T. F., male, aged 61 years, single, watchman, No. 236,880, was admitted to the Los Angeles General Hospital on October 25, 1925, complaining of paralysis of the right lower extremity. A short time prior to admission the patient got into an argument with some acquaintances and was stabbed in the back. He was intoxicated at the time and does not remember much of what occurred. Examination on October 26, 1925, revealed a man of 60, who looked the worse for wear, both eyes were closed and ecchymotic. There was a stab wound in the midline between the second and third dorsal spines, also another stab wound in the left elbow. The right lower extremity was completely paralyzed and flaccid. The left lower extremity could be moved normally. No objective sensory changes were made out, although one would expect impairment on the right side. The right knee jerk and Achilles tendon jerks were gone; left present. No Babinski or ankle clonus was present right or left. X-rays of the upper dorsal spine failed to reveal a fracture in the region of the stab wound. The case was considered one of a stab wound of the cord without much penetration of the latter structure.

On November 2, 1925, one week later, patient began to move the right lower extremity. He regained the strength of this leg rapidly, although the flexors remained weaker than the extensors. The patient was not operated upon.

Case 6. Stab wound of the back between the first and second thoracic spines; Brown-Séquard's syndrome with paralysis of the right leg and numbness of the left immediately following. Exploration of the cord revealed a stab wound of the right posterior column; gradual improvement in all symptoms.

W. J., male, aged 19 years, single, negro, rancher, No. 254,408, was admitted to the Los Angeles General Hospital, on September 12, 1926. About 8:00 o'clock on the previous evening he was stabbed in the back and immediately afterward found that he could not use his right leg and that his left leg felt dead, although he could move it. He stated that he suffered no pain at the time he was struck.

Examination revealed a young adult in good physical condition. There was a stab wound, about 3 millimeters in length, between the first and second thoracic spines from which fluid was draining. There was practically complete paralysis of the right lower extremity, the left could be moved normally. On the left side there was diminution of all forms of sensation ending quite abruptly at the level of the third thoracic segment. There was also slight diminution of sensation on the right side ending at the same segment (Fig. 6). X-ray examination of the dorsal spine failed to reveal a fracture. The blood Wassermann was negative.

On September 14, 1926, a laminectomy was performed, the spines of the first, second, and third dorsal vertebræ being removed. The stab wound could be followed from the surface directly into the spinal canal. It penetrated the dura near the midline and entered the cord in the right lateral column posteriorly (Fig. 7). The cut was in a longitudinal direction and measured only about 1.5 millimeters at the point of entrance to the cord. It was estimated that it did not penetrate the cord more than 1 to 2 millimeters. The surrounding cord was somewhat swollen and red, but no spinal fluid was found in the canal.

On the following day the patient's temperature rose to 104 degrees, the neck became moderately rigid, and a suggestive Kernig sign was present on either side. Two days later these symptoms began to clear up, and by the fourth day his temperature was normal and these signs of meningeal irritation had disappeared. On September 21, 1926, one week after operation, there was a noticeable return of sensation on the left side and a slight knee kick was obtained on the right. On September 23, 1926, he began moving the right lower extremity slightly and by the 25th he could flex and extend the knee and adduct the thigh (Fig. 8). From this time on

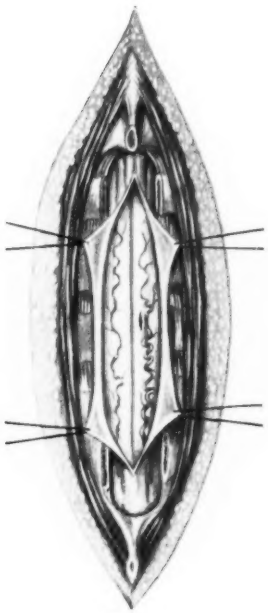

Fig. 7.

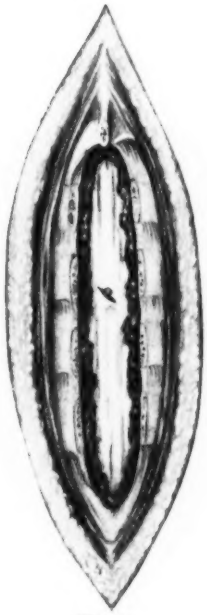

Fig. 10.

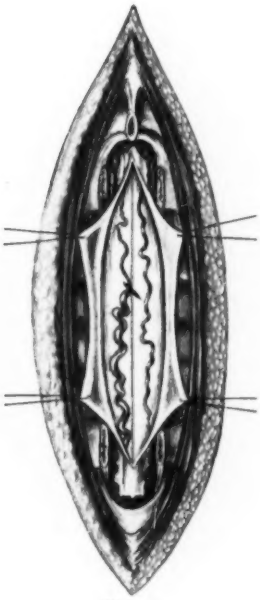

Fig. 11.

Fig. 7. Case 6. Sketch showing small stab wound in the right dorsal column. Symptoms of fairly typical Brown-Séquard syndrome following injury. Recovery almost complete.

Fig. 10. Case 7. Sketch showing findings when dura was exposed. A large extradural clot was present and a dilated vein knuckled through the stab wound in the dura.

Fig. 11. Case 7. Dura opened. The stab wound penetrates the cord at practically the midline. The left vein is dilated. Cord very œdematous and swollen.

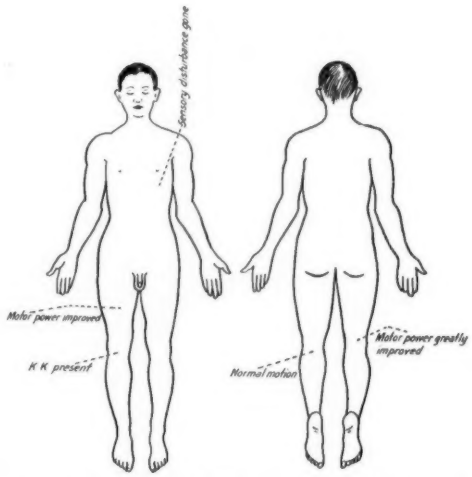

Fig. 8. Case 6. Chart showing almost complete recovery 2 weeks after laminectomy.

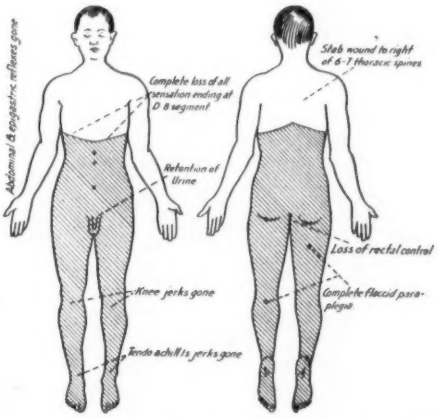
Abdominal & epigastric reflexes gone
Complete loss of all sensation ending at D 8 segment
Retention of Urine
Knee jerks gone
Tendo achillis jerks gone
Stab wound to right of 6-7 thoracic spines
Loss of rectal control
Complete flaccid paraplegia

Fig. 9. Case 7. Diagram showing findings of practically a complete cord lesion following stab wound.

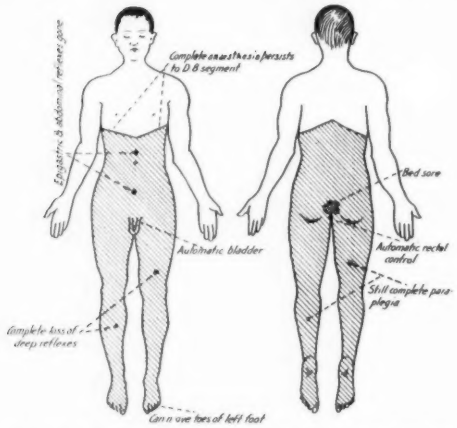
Complete anaesthesia persists to D 8 segment
Epigastric & abdominal reflexes gone
Bed sore
Automatic bladder
Automatic rectal control
Still complete paraplegia
Complete loss of deep reflexes
Can move toes of left foot

Fig. 12. Case 7. Diagrammatic chart of findings showing condition practically 4 months after laminectomy. Very little improvement except some movement of the left foot.

his recovery was gratifying, motor power improved, and sensory disturbance disappeared.

Case 7. Stab wound of the back 5 centimeters to the right of the sixth and seventh thoracic spines; syndrome of complete cord interruption immediately following. Slight changes within 48 hours indicating Brown-Séquard type. Exploration of cord revealed stab wound of the right half of cord. Gradual improvement.

L. H., male, aged 24 years, single, Mexican, laborer, No. 291,797—12,129, was admitted to the Los Angeles General Hospital on April 22, 1928. During the evening he got into a fight with three other Mexicans and was stabbed in the back with a knife. He became immediately paraplegic. He stated that there was no pain associated with the blow; but he lost all feeling from the waist down.

Examination revealed a young Mexican of muscular build, who was quite clear mentally. In the back about 5 centimeters to the right of the sixth and seventh thoracic spines was a stab wound measuring approximately 1 centimeter in length. This was closed with two sutures. No spinal fluid came from the wound. The muscles of the back on the right side were considerably swollen and tender. He presented the picture of a complete cord lesion with a sensory level ending abruptly at about the eighth dorsal cord segment. There was complete anæsthesia to touch, pain, temperature, muscle, joint and vibratory sense, corresponding with this level. There was a loss of all superficial and deep reflexes below this level. Marked priapism developed and remained for about 15 hours. There was complete retention of urine and considerable bloating (Fig. 9). The blood Wassermann was negative. A lumbar puncture carried out on April 24, 1928, revealed a bloody spinal fluid under 75 millimeters pressure. Queckenstedt's test showed a partial block. When jugular compression was applied for 10 seconds the spinal fluid rose approximately 75 millimeters, but it did not come back to the original level for 3 minutes and 15 seconds. A second test again showed a rise of 75 millimeters in the fluid in 10 seconds which did not return to the original level for over 3 minutes. Spinal fluid showed red blood cells 4,000; globulin increased, sugar normal, polymorphonuclear leucocytes 26. X-ray of the spine revealed no fracture, or foreign body.

On April 24 the patient was still completely paraplegic with a loss of abdominal, epigastric, and cremasteric reflexes as well as of all deep reflexes below the level of the lesion. There was, however, a moderate plantar flexion of the toes of both feet in carrying out Babinski's test. There was, furthermore, a slight return of muscle, joint, and vibratory sense on the left side, but not on the right. His temperature on admission was 101 degrees; pulse, 120; respirations, 24; red blood cells, 4,000,000; white blood cells, 12,500.

On April 25, 1928, there was no improvement from the preceding day. An exploratory laminectomy was carried out on April 26, 1928. No bony injury to any spines or laminæ was encountered. After removal of the fifth, sixth, and seventh spines the tissues between the fifth and sixth laminæ were found to be bluish and bulging. Removal of the laminæ revealed the space occupied by epidural fat and areola tissue to be of purplish color. This entire space was filled with a blood clot. The dura seemed compressed forward in the canal and upon the exposure of this membrane the puncture wound was seen. This puncture wound took the form of a minute three cornered tear. It measured approximately 3 millimeters in the long diameter which ran parallel with the cord and about 1 to 2 millimeters across. A large pial vein pushed up in the slight rent made by the dural defect (Fig. 10). When the dura was opened the cord was found to be œdematous and swollen, particularly below the point of injury. The stab wound of the cord was in approximately the midline posteriorly and took a slightly diagonal direction. It was about 3 millimeters across and a probe could be gently introduced about 2 millimeters into its depth. The edges of this wound pouted slightly. On the left side the posterior pial vein was considerably enlarged and more tortuous than the right (Fig. 11). There was no free blood in the subdural space. There was no appreciable enlargement of the vessels above the stab wound. The dura was closed as this could be done without unduly compressing the cord.

On May 3, 1928, it was noted there was much blood and pus in the urine, also that a large trophic ulcer was present over the sacral area, and on the heels. The patient ran a somewhat critical course, but by July 13, 1928, the bladder cleared up to a great degree, and the bed sores were improving under light treatment and balsam of Peru dressings. At this time the sensory level was the same, and

there was no motion of either extremity, except that of the toes of the left foot which could be moved slightly. By August 12, 1928, the patient could lift himself with the aid of a handle bar which was suspended above his bed, and the trophic ulcers were healing. No change in sensory level was apparent (Fig. 12). At this time patient was transferred to the Country Farm for further treatment.

SUMMARY

Stab wounds penetrating the spinal cord are not infrequently seen in large emergency hospitals. The initial symptoms are often those of a complete cord lesion. In the majority of cases, these symptoms change as time passes, usually becoming Brown-Séquard in type. The degree of recovery varies, depending largely upon the extent of original cord injury.

Laminectomy is indicated when a foreign body or bone fragments are present in the spinal canal. Lumbar puncture with Queckenstedt's test should be carried out, to determine whether there is free blood in the spinal fluid, or whether a block exists. Exploration will depend largely upon these findings. Cerebrospinal fluid leaks occasionally are seen and should be closed.

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THE MECHANISM OF PYELOVENOUS BACKFLOW

Its Clinical Significance

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In recent years much has been written concerning a phenomenon which has come to be known as "pyelovenous backflow." Attention was probably first attracted to it by the appearance of radial shadows in X-ray pyelograms, extending outward from the kidney calyces into the parenchyma. Writers called attention to it and very correctly cautioned urologists against the use of abnormal pressures in injecting opaque solutions into the kidney pelvis, for they felt that the appearance of these peculiar shadows was due to extravasation of the fluid from the kidney pelvis outward into the substance of the kidney.

More recently the experimental production of these shadows in human and animal kidneys has been accomplished, and studies have been made in an attempt to establish the mechanism whereby such shadows occur as well as the probable meaning of them. Two workers (1) who sought to produce the phenomenon and who used live animals for their experiments, were unable to find any evidence that backflow had occurred in any of their specimens. But others (8) have been more successful and have produced shadows in the kidneys of different kinds of animals as well as in the human. In fact, they were able to produce the shadows in 78 per cent of all kidneys, of various types, and in 88 per cent of all human kidneys injected. In human kidneys, pressures of 70 millimeters of mercury or less were required (8). Inasmuch as the kidney is known to produce secretory pressures up to 100 millimeters of mercury when its outlet is completely and suddenly obliterated, these results at once engage the attention of every one interested in urologic pathology. They seem to demand further explanation as regards their meaning and their bearing on renal physiology.

The explanations have been offered by several of those who accept the phenomenon as occurring within the physiological limits of the human kidney, although the exact mechanism has not been conclusively demonstrated by them. The concensus of opinion seems to be that pyelovenous backflow is a "safety-valve" mechanism, whereby the kidney is saved from pressure atrophy, when its normal excretory channel becomes blocked sufficiently to raise intrapelvic pressure to a dangerous degree. This is accomplished, they feel, by opening up hitherto closed channels leading from the pelvis directly into the venous bloodstream, thus draining the urine into the renal veins and reducing a pressure, which might cause harm if constant for any considerable period of time. This explanation at once challenges interest, for it has no known analogue in human physiology.

It seems important therefore, that the mechanism of pyelovenous backflow be studied further and that its relation to the economy of the kidney be ascertained. But first of all, its occurrence in the human kidney within physiological limits of pressure must be established.

A study of the human kidney has been carried out with these points in mind. The experiments have been made as carefully as possible in the hope that they might demonstrate the mechanism of pyelovenous backflow as well as its incidence and something of its relation to the normal kidney and renal physiology.

MATERIALS

Human kidneys removed at autopsy were used throughout the study. The time of death of the subject was ascertained in each case so that the comparative degree of autolysis could be known. At death the bodies were placed in a modern, dry, refrigerated room. As soon as the kidney was removed from the body the experiment was made. As will be seen in the protocol these kidneys ranged in postmortem age from 1 to 48 hours.

Only such kidneys as appeared to be normal in the gross were used.

TECHNIQUE

The kidneys were placed in normal saline solution in an incubator at 37 degrees C. for 1 hour to bring them to body temperature. The vascular channels were then washed out with normal saline solution, injected at normal blood pressure through the renal artery—the object being to remove all possible obstacles, on the venous side, to backflow. The injection apparatus was then disconnected from the renal artery and secured firmly to the ureter. A mercury manometer was connected in series, the precaution being taken to have it on the same level as that occupied by the kidney. The ureter and pelvis of the kidney were then injected with one or other of two masses. One mass was composed of 5 per cent neutral gelatin made up in Locke's solution and colored with India ink. The other was 10 per cent India ink diluted with Locke's solution. Both masses were maintained at body temperature. The gelatin mass seemed to be open to criticism because its viscosity was much greater than that of urine and might not, therefore, inject channels or spaces as easily or as completely as the latter. However, it possessed the advantage that wherever it penetrated it could be fixed by chilling and the action of formalin. For this reason it was used with the India ink-Locke solution as a control. As may be seen by examination of the protocol, no practical difference seemed to exist between them. One mass seemed to produce the phenomenon as frequently as the other, and the extent of the vascular tree occupied by the masses seemed to be analogous. However, the gelatin gave much more clearly defined injections for examination under the binocular microscope.

The pressures were applied for periods of 15 minutes each, commencing at 20 millimeters of mercury and progressing in 20 millimeter jumps. This was continued until the mass flowed freely from the renal vein or, if this did not occur, until the periphery of the cortex showed clearly that there was extensive injection of the small veins beneath it, or until such a pressure had been reached and maintained for such a time that it was obvious that there was to be no backflow.

Fig. 1. An X-ray photograph showing injection of the veins by the opaque solution. This occurred in a patient who had had a perinephritic abcess, and had hydronephrosis and hydro-ureter on the opposite side at the time this picture was made.

The ureter was ligated before the pressure was released and the kidney placed in cold 20 per cent formalin. The kidney was fixed in the gross so that, particularly in the case of the gelatin mass, there would be no opportunity for further extension, extravasation, or blurring of the tissues by the wiping of the knife blade as it passed through them. The kidney was then cut in several directions so that a section was made from the cortex to the papilla through each pyramid. Tissues were taken from each pyramid showing injection and were prepared for study in three ways. One set of sections was dehydrated, imbedded in paraffin, cut in thin serial sections, and stained with hæmatoxylin and eosin. This series served as a control for

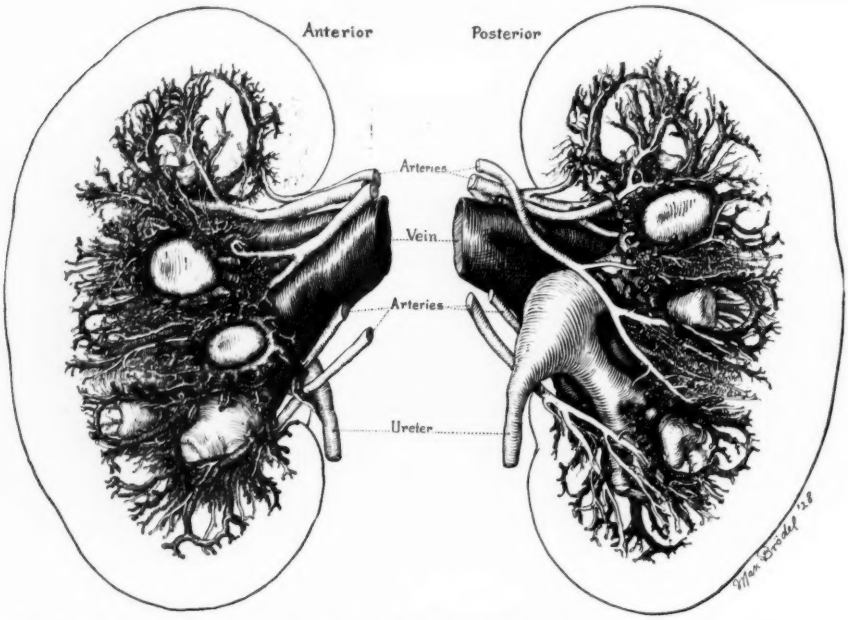

Fig. 2. The anterior and posterior views of a corrosion-injection specimen of the human kidney. Many of the arcuate veins have been cut away to demonstrate the venous collars about the neck of each minor calyx. Some of these are loose loops while others are snugly applied.

possible pathological conditions not seen in the gross specimen—a very important step as will be appreciated later. Another set of sections consisting of thin slices, which were arranged serially and were made through one-half of the pyramid, was dehydrated and cleared in benzol and methyl salycilate according to the method of Spalteholtz. A third series of sections was macerated in 75 per cent hydrochloric acid for microscopic disection. A series of 36 human kidneys was prepared in this manner.

The material thus prepared proved satisfactory for the purpose in mind, for in the cleared specimens the extent and position of the injection mass could be seen with the greatest clearness. The macerated material made possible the clearing up of certain points by actual dissection, where the thinness of the cleared sections prevented their absolute demonstration such as the continuity of vessels, the relation of pelvic veins to peripelvic fat, etc. The stained serial sections were helpful in demonstrating the presence or absence of pathological lesions, the degree of autolysis present, and the location of tears in the veins.

ANATOMICAL CONSIDERATIONS

To understand properly the mechanism of pyelovenous backflow, an accurate conception of the anatomy of the region about the tip of the renal calyx is essential. A knowledge of the course of the renal veins is particularly important. A number of years ago Mr. Max Brödel made an exhaustive study of the circulation of the kidney. By means of many injection-corrosion specimens and beautiful drawings he demonstrated the vascular anatomy of the kidney most completely and satisfactorily (6). Mr. Brödel very kindly allowed me the use of his corrosion-injection preparations which are as beautiful today as when he made them originally in 1899. I wish to take this opportunity to thank Mr. Brödel for his drawings

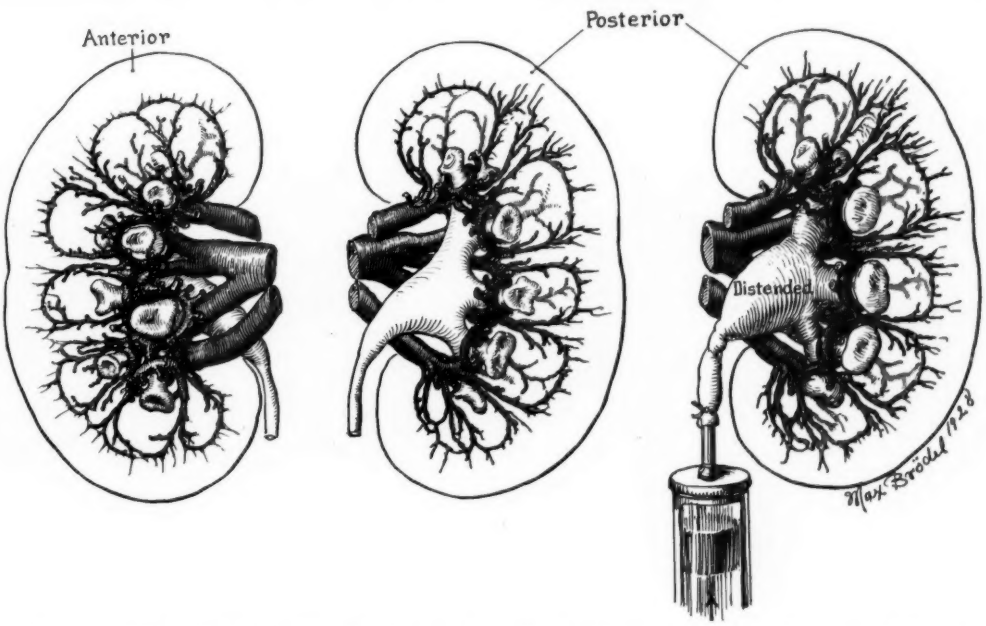

Fig. 3. A simplified drawing demonstrating the inner and outer anastomotic venous circulation of the kidney. The relation of the inner venous collars to the minor calyces is shown with the pelvis undistended and distended.

which illustrate this study, the use of his many beautiful injection preparations, and for his helpful criticism during the progress of the work.

Instead of commencing with the stellate veins of the cortex and the venulæ rectæ of the medulla and progressing toward the large renal veins, as is customary and logical in descriptions of the venous circulation, we will proceed in the opposite direction because in considering pyelovenous backflow we are dealing with a retrograde process. The renal vein divides into several large branches which lie in various planes about the renal pelvis. These in turn again divide into two groups of major vessels. One group passes through the fat filled sinus renalis into the columns of Bertini and courses corticalward to the junction of the medulla and cortex. Here it anastomoses with its fellows to form the arcuate veins. The other group remains in the sinus renalis and anastomoses with its analogue which has usually passed to the other side of a minor calyx. Thus there are two major systems of venous anastomosis; an outer one and an inner one. The outer system drains the stellate and intralobular veins of the cortex and the venæ rectæ of the medulla. The inner system supplies a shunt between the branches forming the outer anastomotic system. In a large proportion of the cases the inner anastomosis forms a venous collar, if it is complete, or a venous loop, if it is not complete, about the neck of the calyx. In the anterior group of calyces the veins nearly always form the complete venous ring about the fornix of the calyx. About the posterior calyces the venous anastomis sometimes takes the form of a complete collar but more frequently is incomplete and forms only a loop (Fig. 2).

The inner venous anastomotic ring or loop lies in the peripelvic fat of the sinus renalis and forms a collar about the neck of the calyx at a point usually just below the level occupied by the tip of the papilla, so that the sharply angulated tips of the fornices of the calyces lie well above and within its circle.

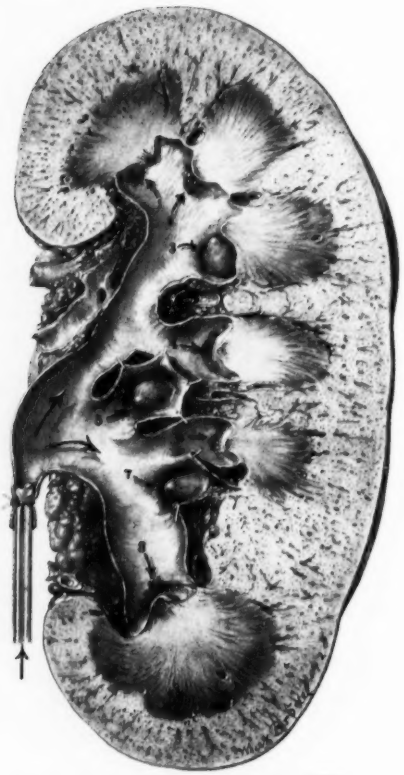

Fig. 4. One-half of a human kidney in which pyelovenous backflow has taken place. There are points of rupture in the fornices of every minor calyx. The injection of the arcuate veins and the stellate veins is shown. The extravasation of the ink into the fat of the sinus renalis is quite evident.

A comprehension of this relation is fundamental to an understanding of the mechanism of pyelovenous backflow and is therefore shown from several points of view in figures 2, 3, 5, and 6.

THE MECHANISM OF PYELOVENOUS BACKFLOW

When the renal pelvis becomes distended all portions may expand excepting that which is reflected over the papilla, for the reason that the whole pelvis is surrounded by a resilient medium, principally areolar tissue filled with fat, which allows it to give way to internal pressures, with the exception of that area represented by the papilla. This area is supported by fairly compact tissue composed of collecting ducts surrounded by connective tissue. Therefore, when the pelvis dilates, the sharply angulated fornices of the calyx round out, becoming more obtuse or arcuate in shape (Fig. 7). If dilatation is carried far enough, rupture occurs. Such rupture is found uniformly at the tip of the fornix where the tissues surrounding the pelvis change from those which are elastic to those more or less dense and less yielding. An accessory factor predisposing to rupture at the fornix of the calyx is, probably, the course of the connective tissue fibers in the wall of the pelvis. At the fornix they divide to form a T, a few fibers being reflected onto the surface of the papilla where they gradually thin out, while the main sheet continues upward into the column of Bertini, to form a dividing septum between contiguous pyramids. This, presumably, makes the fornix much weaker than any other point in the pelvis. It would seem quite probable that the factors controlling the locus of rupture have a mechanical basis because the rupture is always at this point, whether the kidney is diseased or not.

The rupture of the pelvis allows extravasation of the pelvic contents into the fat laden sinus renalis with its arterial and venous trunks. If, as sometimes happens, this is the only damage done, there is no pyelovenous backflow, but merely an extravasation into the sinus renalis and upward along the connective tissue septa between the pyramids. Usually, however, when sufficient pressure has been exerted to rupture the renal pelvis, the dilatation has been great enough to place tension upon the thin walled venous collar, which often surrounds the calyx, and has been great enough to tear it. From the proximity of the tip of the fornix to these venous rings one can easily understand how, in the event of tears in both, fluid would find its way into the blood stream rapidly and in large amount. Once in the arcuate veins, the mass injects the stellate and intralobular veins to the periphery of the cortex and the venæ rectæ for a short distance

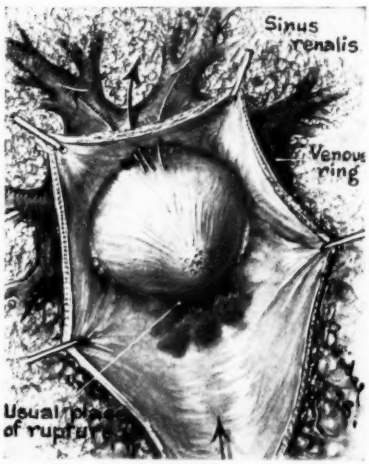

Fig. 5. A minor calyx opened to show multiple points of rupture at the margins of the papilla where the pelvis is reflected over the papilla. The relation of the point of rupture to the venous ring and the pathway of the injection mass is indicated.

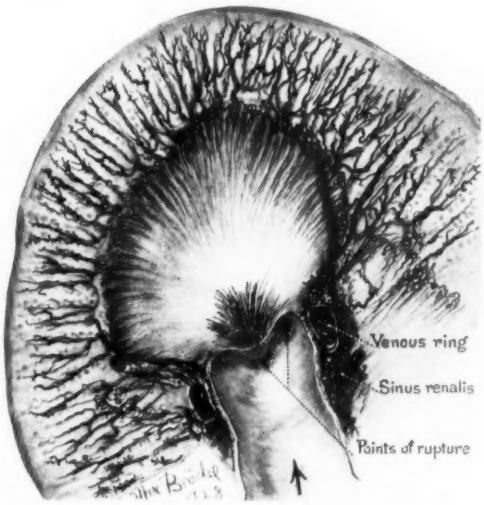

Fig. 6. A longitudinal section through a renal pyramid and minor calyx. The relation of the points of rupture to the venous ring and the arcuate veins is seen as well as the injection of the interlobular veins and the venæ rectæ. The injection of the collecting ducts through the papillary foramina is shown to extend a short distance into the medulla.

down into the medulla and, of course, frequently emerges from the renal vein.

In the serial sections these tears in the thin walled veins can sometimes be demonstrated. To those who have attempted such a demonstration no allusion to its difficulty need be made. To be absolutely sure that a given tear has been caused by the force of an injection fluid, and that it is not an artifact caused by the microtome knife or faulty imbedding, is a point requiring nice discrimination. It must suffice to state that tears have been found which to a number of trained observers seemed in all likelihood to be due to fluid pressure. These tears have all occurred either in the venous ring itself or in the ascending branch at a point so close that dilatation of the calyx with attending strain upon the connective tissue septa could have caused them. In the cleared serial sections the distribution of the ink in the tissues is such that the point of entry of the injection fluid into the vein is easily proved to be in one or the other of the thin walled veins of large caliber; that is, in the inner anastomotic ring or in the ascending branch of an arcuate vein very close to its junction with the venous ring. In other words, there does not seem to be any possible doubt as to the pathway traversed. The only question that does seem not to be absolutely demonstrated, or demonstrable, is the most usual site of tear in the vessel. Indeed, it is most probable that this varies somewhat. In our series of specimens it did seem to vary over a distance of about 0.5 centimeter.

Despite these minor difficulties, we feel that this is the correct explanation of the phenomenon as it has been traced repeatedly in the cleared sections and serial sections, as well as verified by dissection of the macerated specimen.

The injection mass usually enters some of the papillary ducts and passes a short distance upward into the collecting tubules. It rarely extends so far as the injection coming down through the venulæ rectæ. It is needless to say that there is no connection between them. Figure 7 presents our concept of the mechanism of pyelovenous backflow.

The pathway of the injection mass from the pelvis into the venous channel does not

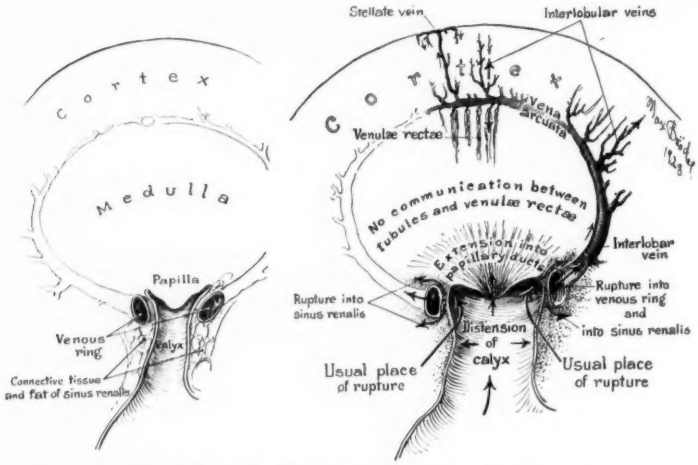

Fig. 7. A schematic drawing illustrating the effects of distention of the calyx and the pathways followed by the injection mass in the production of pyelovenous backflow.

always lead directly from the point of rupture into the nearest venous collar; this is not always torn. But it may permeate the peri-pelvic fat, forcing its way through lines of cleavage, creating a reservoir of fluid under tension in the sinus renalis, and eventually seep outward beneath the renal capsule. Occasionally, after traversing a portion of the sinus renalis, connection is made with a distant venous collar that has been torn, with subsequent injection of the venous system. This has been observed in two of our specimens.

The route of injection has been described by some writers as being from the point of rupture in the pelvis into the venæ rectæ of the medulla and thence into the arcuate vessels. In all likelihood this is not correct. The venæ rectæ are not injected except for a short distance downward from the arcuate vessels. Furthermore, it would seem impossible to account for the occurrence of massive injection of the venous tree, if such narrow channels as the venulæ rectæ were the connecting link.

OCCURRENCE OF PYELOVENOUS BACKFLOW

A study of the protocol of the experiments reveals that in 36 kidneys, 20 came within the definition of pyelovenous backflow, that is, the injection mass either flowed freely from the renal vein or was observed in the stellate veins beneath the capsule, at the pressure indicated. In 55 per cent of the kidneys, then, there was rupture of the pelvis and extravasation into the arcuate veins. This, however, is not as high a percentage as has been described by other investigators.

The significance of this figure is modified further by examination of the stained microscopic sections, as indicated in the protocol. In no kidney was pyelovenous backflow produced at pressures below 100 millimeters of mercury, where there was not present either some definite pathological factor or autolysis of the kidney tissues. On the contrary, a number of the fresh normal kidneys withstood pressures as high as 220 millimeters of mercury without rupture of the pelvis. All of the normal, well preserved kidneys withstood pressures of at least 120 millimeters of mercury without rupture. This would seem to indicate that pyelovenous backflow was definitely not a normal mechanism but rather one associated with pathological changes in the tissues plus increased pelvic pressure; that increased pressure alone within

PROTOCOL

No.	Flow from renal vein	Injection of cortical veins	Postmortem age	Positive or negative	Injection mass	Pathological changes	Pressure*	Autolysis
1	0	0	1½ hr.	0	5% gelatin India ink	0	220	None
2	+	+	36 hr.	+	1–10 India ink Locke solution	0	30	Marked
3	0	+	8 hr.	+	5% gelatin India ink	0	120	None
4	0	0	2 hr.	0	5% gelatin India ink	0	140	None
5	+	+	36 hr.	+	5% gelatin India ink	Slight chronic nephritis	30	Moderate
6	0	0	1 hr.	0	5% gelatin India ink	0	160	None
7	0	0	30 hr.	0	5% gelatin India ink	0	120	None
8	0	+	22 hr.	+	5% gelatin India ink	Small abcesses	40	None
9	+	+	48 hr.	+	5% gelatin India ink	0	60	Marked
10	0	0	4 hr.	0	1–10 India ink Locke solution	Acute pyelitis	125	None
11	0	+	12 hr.	+	1–10 India ink Locke solution	Foci of leucocytic infiltration	120	None
12	0	0	3 hr.	0	1–10 India ink Locke solution	0	220	None
13	+	+	24 hr.	+	1–10 India ink Locke solution	Infarct	70	None
14	+	+	42 hr.	+	1–10 India ink Locke solution	0	80	Marked
15	+	+	14 hr.	+	1–10 India ink Locke solution	Chronic nephritis	100	None
16	0	0	12 hr.	0	1–10 India ink Locke solution	0	160	None
17	+	+	15 hr.	+	1–10 India ink Locke solution	Acute pyelitis	65	None
18	0	0	13 hr.	0	5% gelatin India ink	0	120	None
19	0	0	7 hr.	0	5% gelatin India ink	0	190	None
20	+	+	38 hr.	+	1–10 India ink Locke solution	0	40	Moderate
21	0	+	8 hr.	+	1–10 India ink Locke solution	0	120	None
22	0	0	3 hr.	0	1–10 India ink Locke solution	0	130	None

* Pressures are in millimeters of mercury.

PROTOCOL—*Continued*

No.	Flow from renal vein	Injection of cortical veins	Postmortem age	Positive or negative	Injection mass	Pathological changes	Pressure*	Autolysis
23	+	+	35 hr.	+	1–10 India ink Locke solution	Chronic pyelitis	30	Moderate
24	0	0	10 hr.	0	1–10 India ink Locke solution	0	160	None
25	0	0	31 hr.	0	1–10 India ink Locke solution	0	140	None
26	0	+	24 hr.	+	1–10 India ink Locke solution	Pyelitis slight	40	None
27	+	+	47 hr.	+	1–10 India ink Locke solution	0	60	Marked
28	0	0	4 hr.	0	1–10 India ink Locke solution	0	120	None
29	0	+	11 hr.	+	5% gelatin India ink	0	125	None
30	0	0	5 hr.	0	5% gelatin India ink	0	210	None
31	+	+	24 hr.	+	5% gelatin India ink	Small abcesses	75	None
32	+	+	47 hr.	+	5% gelatin India ink	0	80	Marked
33	+	+	14 hr.	+	5% gelatin India ink	Chronic nephritis	95	None
34	0	0	10 hr.	0	5% gelatin India ink	0	160	None
35	+	+	7 hr.	+	5% gelatin India ink	Chronic pyelitis	65	None
36	0	0	9 hr.	0	5% gelatin India ink	0	140	None

* Pressures are in millimeters of mercury.

the physiological limits of the kidney (100 mm.) could not produce it.

CLINICAL SIGNIFICANCE

The foregoing statements must not be interpreted by those injecting kidney pelves for clinical studies as minimizing the necessity for care in regulating the amount of pressure used. In these experiments all the kidneys used appeared to trained pathologists to be normal upon gross inspection. And yet some of the kidneys ruptured at pressures which were as low as 30 millimeters of mercury.

The clinician often has no means of knowing whether or not he is dealing with a diseased

kidney, and for this reason he should always use some method of injecting the opaque solutions which will ensure safety. Radial shadows extending outward from the calyces of the kidney in the X-ray plate always indicate that damage has been done.

A column of 12.5 per cent sodium iodide solution, 45 centimeters (18 inches) in height exerts a pressure of 30 millimeters of mercury. This pressure is always sufficient for making a pyelogram and probably exceedingly rarely, if ever, will such a pressure cause rupture of the renal pelvis.

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CLINICAL SURGERY

FROM THE WASHINGTON UNIVERSITY SCHOOL OF MEDICINE

SHORTENING OF BROAD LIGAMENTS AND ELEVATION AND REPAIR OF UTEROPUBIC FASCIA FOR UNCOMPLICATED PROLAPSE OF UTERUS AND BLADDER

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EXPERIENCE has shown that uncomplicated prolapse of the uterus and bladder, no matter how severe, can be permanently corrected without the extensive abdominal operations or the extensive vaginal operations frequently employed for it. Abdominal operation is required in prolapse only when there is some complicating condition necessitating abdominal section. Vaginal hysterectomy is required only when there is some complication necessitating removal of the uterus.

The broad ligaments are the main supporting structures of the uterus in the upper pelvic plane. The principal part of the supporting tissue of each broad ligament lies in the lower portion, forming a strong mass of tissue extending from the cervix uteri outward and upward to the pelvic wall in the region of the "white line." So important is this in supporting the uterus that it has long been designated the "ligamentum cardinale." In all cases of uterine prolapse this "ligamentum cardinale" of each side is stretched out to undue length—it must be, otherwise the uterus could not sink into prolapse. When this strong portion of the broad ligament of each side is adequately shortened, a most important step has been taken toward permanent correction of the prolapse. The lower portion of the broad ligaments may be shortened by simple coaptation in front of the cervix or by division and overlapping in front of the cervix. The former method was devised in 1903 by Aleksandroff[1] and the latter in 1906 independently by Dudley[2] and Hertzler.[3]

The uteropubic fascia supports the base of the bladder. In the extensive disturbances of parturition resulting later in prolapse of the bladder, the supporting power of the uteropubic fascia is damaged in two particulars. First, its uterine attachment is displaced downward toward the end of the cervix and, second, it is greatly overstretched in all directions. The *downward displacement* of the uterine end of the fascia is corrected by restoring its attachment high on the uterus, which is an important step in operating for bladder prolapse. This step aids also in correcting the uterine prolapse, for when this fascia is properly attached above the pivotal area of the uterus, it tends to keep the corpus uteri forward and the cervix back. This downward displacement of the attachment of the fascia and vaginal wall in prolapse, and the necessity of elevation of the same, were recognized as early as 1889 by Hadra[4] of Texas who set forth his views in a most interesting and instructive paper. Gradual improvement since then has given the present effective and simple technique for elevation of the uterine attachment of this fascia. The *overstretched* condition of the uteropubic fascia is corrected by the excision or the overlapping of the redundant portions, thus restoring the side-to-side sling-support under the bladder. The importance of this fascial layer under the bladder, and the necessity of eliminating the laxity by coaptation of certain portions, was described and illustrated by Martin of Germany in his book published nearly twenty years ago. Additional instructive articles on the anatomy and surgery of this region by later workers have contributed to the satisfactory method of suture-approximation now in use. The overlapping method, in which the fascia is separated from the vaginal wall and the redundant portions overlapped, was developed independently by Rawls[5] and Neel.[6] The anatomical and mechanical features of this overlapping method have

[1] Russk. Vrach, S. Peterb., 1903, xi, 449.
[2] J. Am. M. Ass., 1906, xlvii, 1605.
[3] J. Am. M. Ass., 1907, xlviii, 277.
[4] Am. J. Obst., 1889, xxii, 457.
[5] Am. J. Obst., 1919, lxxvii, 359.
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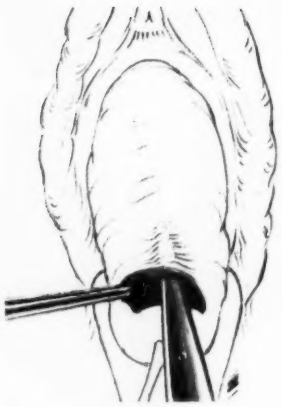

Fig. 1.

Fig. 2.

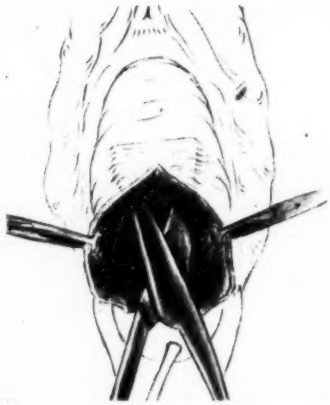

Fig. 3.

Fig. 1. Beginning the separation of the vaginal wall. With the scissors an opening has been clipped in the wall overlying the cervix. The edge of the opening has been raised and the blunt scissors-point thrust under the vaginal wall and attached uteropubic fascia, separating them from the bladder.

Fig. 2. Scissors opened, widening the area of separation. By repetition of this process of thrusting forward the blunt scissors a short distance and then opening the blades, the desired separation may be made rapidly and safely. As the blunt scissors-point is pushed forward, it should be directed against the vaginal wall and away from the bladder wall so that the danger of injuring the bladder wall may be eliminated.

Fig. 3. The separated wall is divided as necessary to facilitate separation higher.

quite an appeal, but after employing it for a time I went back to the simple approximation method described below, which ordinarily accomplishes what is necessary in less time and with less tissue disturbance. In exceptional conditions, however, overlapping may be decidedly advantageous.

TECHNIQUE

The combination operation for shortening of the broad ligaments and elevation and repair of the uteropubic fascia is carried out in the following steps: (1) separation of vaginal wall from bladder; (2) separation of bladder from uterus; (3) exposure of lower part of each broad ligament; (4) placement of broad ligament sutures; (5) excision of excess fascia and vaginal wall; (6) placement of fascia-elevating sutures; (7) the tying of broad-ligament sutures and then of fascia-elevating sutures; (8) completion of the suturing of fascia and vaginal wall; and (9) repair of pelvic floor.

1. *Separation of vaginal wall from bladder.* This step may be conveniently begun by making a small incision with scissors just in front of the cervix (Fig. 1) and then working forward with the blunt scissors between the vaginal wall and the bladder. The separation may be made rapidly and safely by thrusting the closed scissors forward a short distance under the vaginal wall and then opening them as indicated in Figures 1 to 3. This process is kept up until the required separation in the median line has been secured. The blunt point of the scissors is to be directed against the under surface of the vaginal wall to avoid injury to the bladder wall. The separated vaginal wall is divided as needed for advantageous work (Fig. 3). After the separation in the median line is completed gauze dissection is employed to separate the vaginal wall laterally (Fig. 4). This lateral separation is continued on each side around the bladder until the bladder can be picked up, as shown in Figure 5.

If preferred, the separation of the vaginal wall may be begun by a median incision with the knife. The incision passes through the vaginal wall proper and the underlying attached fascia. There are two planes of cleavage: one, not very apparent in the median line, between the vaginal wall and the fascia; and the other, more evident, between the fascia and the bladder wall. The separation should take place along the latter plane, so that the fascia remains attached to the vaginal wall. This cleavage plane between the fascia and bladder wall is most easily identified in the posterior part of the incision near the cervix, consequently it is well to begin the separation there.

2. *Separation of bladder from uterus.* Laterally, the bladder is easily pushed off the cervix, but in the median line it is usually held by some connective tissue fibers which must be divided with scissors or

Fig. 4.

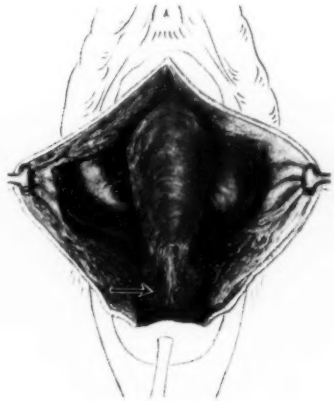

Fig. 5.

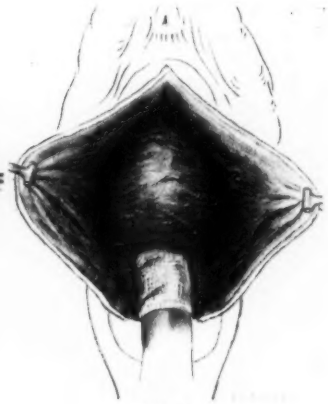

Fig. 6.

Fig. 4. The vaginal wall with attached uteropubic fascia has been separated and divided all along the median line. The separation has been made well around the bladder on the patient's left side and is being made on the right side. This separation may be made rapidly by gauze dissection as indicated.

Fig. 5. Picking up the bladder to identify the vesico-uterine fibers that must be cut to facilitate separation of the bladder from the uterus. The arrow indicates the safe area in which to cut these fibers, i.e., down near the uterine wall.

Fig. 6. After the vesico-uterine fibers shown in Figure 5 have been divided, the bladder may be easily pushed off of the uterus by the gauze-covered finger as here shown. The bladder separation is continued up to the area of the vesico-uterine peritoneal fold, and then a retractor is introduced to hold the bladder out of the way of the subsequent work, as shown in Figure 7.

knife. This group of fibers, which has been designated the uterovesical ligament, is indicated by the arrow in Figure 5. It is made tense for identification as shown in the illustration and is divided near the cervix. Then the bladder is easily pushed off the uterus by gauze dissection (Fig. 6) up to the vesico-uterine peritoneal fold.

3. *Exposure of lower part of each broad ligament.* The vaginal wall, with its underlying fascia, is loosened laterally by gauze dissection and then divided with the scissors, as in Figure 7, so as to give good exposure of the lower portion of each broad ligament.

4. *Placement of broad ligament sutures.* These sutures, shown in Figure 8, are of 40 day catgut, No. 1 or 2 as preferred. They take firm hold of the lower part of the broad ligament on each side, far enough out so that when tied they will take up the slack in the ligaments. If there is any doubt as to just how far out to place these sutures, test the selected site on each side by picking it up with a forceps and bringing the two together in the median line, at the same time pushing the uterus back and up in the pelvis. These sutures are left untied and long, and each is held by a forceps (Fig. 9).

5. *Excision of excess of fascia and vaginal wall.* The excess of each flap is trimmed away as indicated in Figure 9. Sufficient flap should be left on each side to permit suturing together in the median line without tension. On the other hand, marked laxness of the repaired structures should be avoided. As a rule, the line of excision will extend from the outer limit of the lateral incision at the cervix, directly forward to the anterior end of the median incision (Fig. 9). During closure of the anterior part of the incision, if the anterior portion of the flaps are found still rather lax, they may be then further trimmed as needed.

6. *Placement of the fascia-elevating sutures.* These sutures, which elevate the uterine attachment of the fascia above the pivotal area of the uterus, are shown in Figure 10. They pass through the trimmed flaps (consisting of vaginal wall and underlying fascia) at about the junction of the middle third with the posterior third (Fig. 10). They take firm hold of the anterior uterine wall just below the vesico-uterine peritoneal fold, that is, one-third to one-half the way up the uterus. The object of this high uterine attachment of the fascia is to hold the corpus uteri forward and at the same time shorten the fascia so as to take out the anteroposterior slack and give good support under the bladder, as shown in Figure 12.

7. *The tying of the main sutures.* The uterus is pushed inside the pelvis and the two broad-ligament sutures are tied, the broad ligaments being folded in front of the cervix (Fig. 11), and the

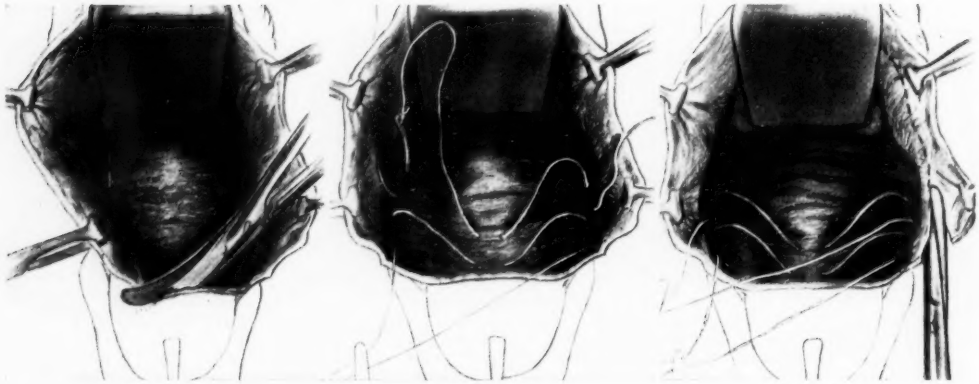

Fig. 7. Fig. 8. Fig. 9.

Fig. 7. The bladder has been separated laterally so that the base of the bladder and ureters are carried up out of the operative field by the retractor. The lower portion of each broad ligament is further exposed, first by gauze separation of the vaginal wall and then by division of the overlying wall, as here indicated.

Fig. 8. The broad ligament sutures, passed as here shown, fold the broad ligaments in front of the cervix and fasten the folded portions to the cervix. These sutures are not to be tied until the fascia elevating sutures have been passed.

Fig. 9. Trimming off the excess of vaginal wall and attached fascia. The trimming is begun at the lateral angle of the wound, as is shown in the illustration, and the cut is extended forward to the anterior end of the vaginal wound.

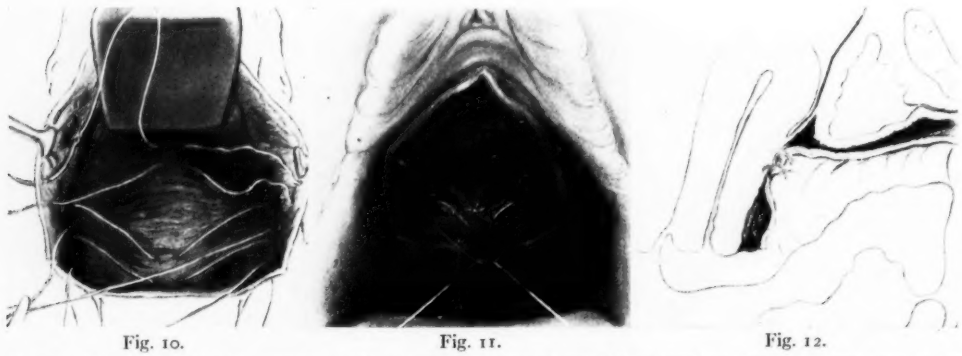

Fig. 10. Fig. 11. Fig. 12.

Fig. 10. The fascia elevating sutures. These sutures elevate the fascial attachment above the pivotal area of the uterus as indicated in Figure 12, and thus the corpus uteri is pulled forward at the same time that the fascia is shortened and the base of the bladder supported.

Fig. 11. Tying the broad ligament sutures. The uterus is pushed into the pelvis, well back and up, and the sutures are tied entirely by touch as the area cannot then be seen.

Fig. 12. Anteroposterior section, indicating the effect of tying the fascial elevating sutures. The fascial attachment is elevated above the pivotal area of the uterus so that the corpus uteri is pulled forward. At the same time the fascia is shortened and the base of the bladder well supported in a high location.

slack being taken up so that the cervix is held well back in the pelvis. The fascia-elevating sutures are then tied. They should draw the corpus uteri forward and also give good support under the bladder (Fig. 12).

It is important to place all the main sutures before any of them are tied, as it is difficult to reach the uterus after tying begins.

8. *Completion of the suturing of fascia and vaginal wall.* A few interrupted sutures complete the closure of the vaginal wound, thus approximating the fascia and attached vaginal wall. The two or three closing sutures required back of the fascia-elevating sutures (Fig. 13) may be placed *before* the main sutures are tied, if preferred. When closure of the anterior part of the wound is begun,

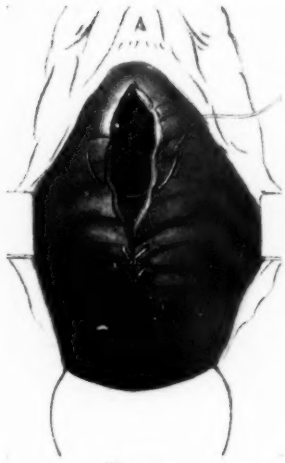

Fig. 13.

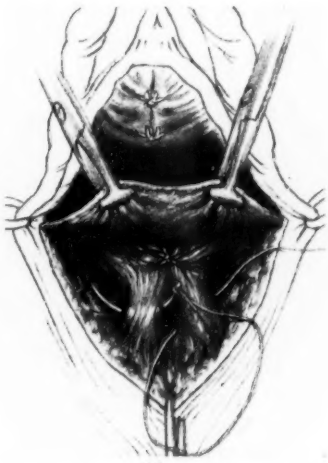

Fig. 14.

Fig. 13. The two fascia elevating sutures are indicated by the heavy knots with rather long ends. The posterior part of the vaginal wound has been closed by two sutures, and the anterior part is being closed. If preferred, the two posterior sutures may be passed before the broad-ligament and fascia-elevating sutures are tied.

Fig. 14. Effective repair of the pelvic floor is an important step in all prolapse operations.

Fig. 15.

Fig. 15. When conical excision of the cervix is required, on account of laceration and cervicitis, it may be conveniently carried out just after the main sutures are passed, as here indicated. The incision has been continued around the cervical opening to include the affected tissue, which is removed as a cone.

if the trimmed flaps are found still too redundant, they may be trimmed further as needed before the closing sutures are placed (Fig. 13). As to suture material, 40-day catgut No. 1 or 2, as preferred, is very satisfactory for use throughout.

9. *Repair of pelvic floor.* Repair of the pelvic floor (Fig. 14) is of course required in all operations for prolapse.

CONICAL EXCISION OF CERVIX

In those cases in which laceration of cervix and chronic cervicitis require excision of the affected area, with the uterus otherwise in good condition for preservation, conical excision is added to the above technique. As the excision of the cystic area of the cervix causes considerable bleeding, it is well to postpone it until the main sutures are in place, as indicated in Figure 15.

The affected glandular area of the cervix is then excised as indicated (Figs. 15 and 16). It is important to excise no more widely nor deeply than necessary to remove diseased tissue. Unnecessarily extensive excision increases the troublesome bleeding and the chance of later stenosis.

An anterior and posterior Sturmdorf suture of chromic catgut will turn in the margins and

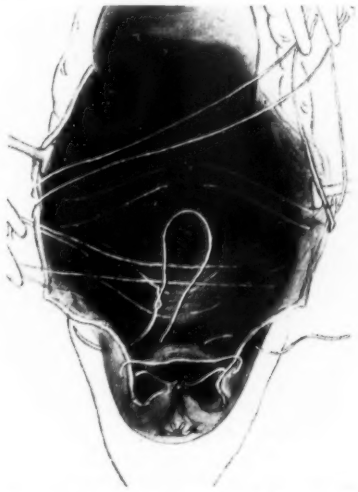

Fig. 16. The cone of affected tissue has been removed, and the posterior Sturmdorf suture passed and tied, drawing in the posterior flap. The anterior Sturmdorf suture is being passed. When this is tied it draws in the anterior flap. Then a suture or two on each side completes the cervix work, and the remaining steps of the operation may be proceeded with as usual.

check most of the bleeding. The hæmostatic effect of these sutures[1] is increased by placing the entrance and exit a considerable distance apart as shown in the illustrations. One or two sutures on each side complete the inversion and hæmostasis. The operator may then proceed with the main operation, by pushing the uterus inside the pelvis and tying the broad-ligament sutures.

FOTHERGILL OPERATION

In this connection mention should be made of the "Fothergill operation," which is used so extensively in England and associated countries. It was described by Fothergill[2] as a colporrhaphy with a special outline of denudation by which the excess vaginal wall is excised. The excision of vaginal wall extends well laterally at the vault, and in most cases there is an excision of the cervix along with the vaginal denudation. After the denudation, the shortened vaginal walls are united in the median line and about the denuded cervix. Though the description of the operation is devoted exclusively to the outline of denudation and the suturing of vaginal wall and cervix, the good results indicate that there is considerable shortening of the broad ligaments and repair of the uteropubic fascia—these two important features being inadvertently included more or less effectively in different cases depending on the details of tissue exposure and the suturing employed by individual operators. Probably many operators purposely pass the sutures into the deeper tissues. In fact, I know one Australian advocate of the operation who recommends placing a special suture to catch up tissue in the broad ligament area.

Experience long ago demonstrated that colporrhaphy (vaginal wall suturing) does not give lasting support against pressure. It was this stretchability of the repaired elastic vaginal wall in the colporrhaphies of pioneer gynecology that necessitated the deliberate study as to the best method of including the deeper strong supporting tissues in the suturing. The result of this extensive study by many workers over a long period is the effective method of shortening the broad ligaments and elevation and repair of the uteropubic fascia explained in this article. Permanent results from the Fothergill operation, or any other method of denudation and suturing, will depend on the extent to which these two essential features are included. These two essential features are not even mentioned in the Fothergill operation, while the particular point that is stressed, namely, the method of denudation, seems to me distinctly disadvantageous. The undue length of time consumed in the operation as I have seen it, could be materially reduced by employing a less tedious method of vaginal-wall dissection and also by omitting the cervical amputation except when really needed.

[1] See Figures 17 and 18, p. 102, Surg., Gynec. & Obst., 1916, vol. xxii.

[2] Am. J. Surg., 1915, xxix, 161.

INDICATIONS

No one operation is best for all cases of prolapse. In this, as in other pelvic lesions, the patient should have the benefit of *selective* treatment. The accompanying conditions differ much in different cases and require different operative methods. In each case the various pathological conditions present should be accurately determined, and then the operative method best meeting those conditions should be employed. Some patients have complications necessitating abdominal section, and in such it may be advisable to complete the operative work for the prolapse by that route, the pelvic floor also, of course, being repaired. The prolapsed uterus may be so diseased that it must be removed, by abdominal or vaginal hysterectomy—the hysterectomy to be followed by adequate steps to restore the upper and lower supporting planes of the pelvis.

In this article, I have considered just one class of cases of prolapse of the uterus and bladder, namely, the *uncomplicated*. This is a large class comprising many patients, and for each of them the operation described (shortening the broad ligaments with elevation and repair of the uteropubic fascia) is very satisfactory. It is simple and effective. It accomplishes what is needed without unnecessary risk from extensive manipulations in the peritoneal cavity or from undue prolongation of the anæsthesia. It is applicable both in the childbearing period and in later life. As already explained, excision of the cervix, when required for chronic cervicitis or cystic change, works in very well as a part of the operation.

There is another operation that divides the field with this one after the menopause, and that is the interposition operation. The Wertheim-Watkins interposition operation, in which the corpus uteri is interposed between the raised bladder and the anterior vaginal wall, is so generally used and well known that a detailed description is unnecessary. For the aged patient with extensive bladder prolapse it has the distinct advantage that it interposes a firm body under the base of the bladder for support, instead of just the connective tissue which is sometimes quite atonic and stretchable in these patients. Either operation may be carried out under regional or local anæsthesia when conditions make it advisable to do so.

FROM THE DEPARTMENT OF SURGERY, EDINBURGH UNIVERSITY

EXCISION OF THE RECTUM FOR CARCINOMA

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A STUDY of the pathology of cancer of the rectum reveals the fact that the disease, in the majority of cases, remains a local one for a considerable period, probably at least a year, after its first beginnings. This fact lends hope to our efforts in radical extirpation. The ideal operation of excision of the diseased segment of the bowel, with the re-establishment of its continuity and the maintenance of the integrity of the sphincters, is so seldom feasible that it cannot yet be considered to be in any sense a standard operation in surgery. Practically all surgeons are agreed that a complete removal of the rectum with its fascial investments and its immediate lymph shed is demanded, and that with this a permanent colostomy must be made.

In favorable subjects the abdominoperineal operation, as so long advocated and practised by Miles, is undoubtedly the operation of choice. Carried out properly in one, but possibly in two stages, it gives a removal of the diseased segment scientifically adequate and technically sound. The disquieting fact remains, however, that in approximately 50 per cent of the cases met with in practice, this operation presents difficulties and risks which are serious, if not unjustifiable, and we are faced with the alternatives of merely adopting an expectant attitude, of doing a palliative colostomy, of treating with radium, or of extirpating the diseased bowel by an operation which is less radical, and therefore from the pathological standpoint less satisfactory, but which involves much less immediate risk, and is therefore applicable in a much wider range of cases. The latter consists of the perineal operation following on a preliminary colostomy, an operation with a very wide range of applicability and a low mortality (less than 10 per cent). It is this operation which we practice as the standard, reserving the abdominoperineal method for the favorable case, viz., the spare, wiry subject of 60 years or under.

DANGERS OF THE OPERATION

The dangers are three in number—shock, hæmorrhage, and sepsis. The first two can be readily eliminated if the excision operation is performed under twilight sleep and spinal anæsthesia. The factor of sepsis can be minimized but not excluded. Gross soiling of the wound may occur from a tear in the bowel at or near the tumor during the operation—a rare accident. A more subtle form of sepsis is that from the severed lymph vessels draining from the infected and ulcerated growth, and this in some degree is inevitable. By careful preliminary treatment this lymph-borne infection can be met successfully.

PRELIMINARY COLOSTOMY

In a case in which the obvious signs of metastasis are absent and the growth is not immovably fixed, the patient is given a general anæsthetic and the abdomen is opened through a mid left rectus incision. Evidence of peritoneal and hepatic involvement is searched for, and, if excluded, the upper limits of the growth and any spread by contiguity established. The presence of palpable glandular involvement along the superior hæmorrhoidal vessels is determined, and if this be not excessive, the feasibility of a subsequent radical operation is clear. The upper portion of the pelvic colon loop is brought out over a glass rod through the upper part of the abdominal wound, which is then closed in layers. Three days later the loop is cut across to establish a permanent colostomy.

PERIOD OF PREPARATION

The length of the interval of time between the colostomy and the radical operation is determined by the general condition of the patient. In cases in which there is a large ulcerating growth, and the patient is exhausted and anæmic, an interval

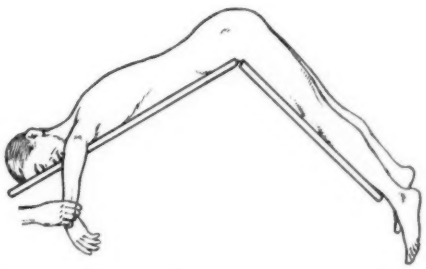

Fig. 1. Diagram showing position of patient for operation.

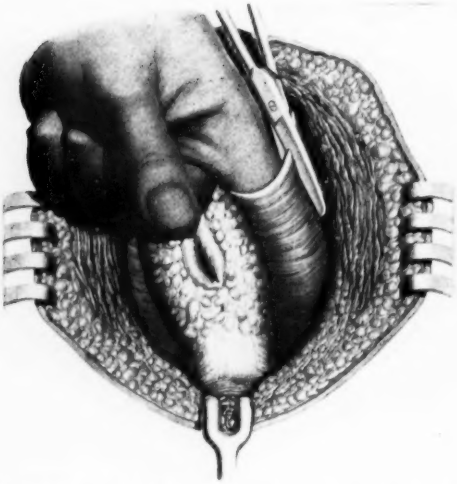

Fig. 2. Division of levator ani muscle near its pelvic attachment.

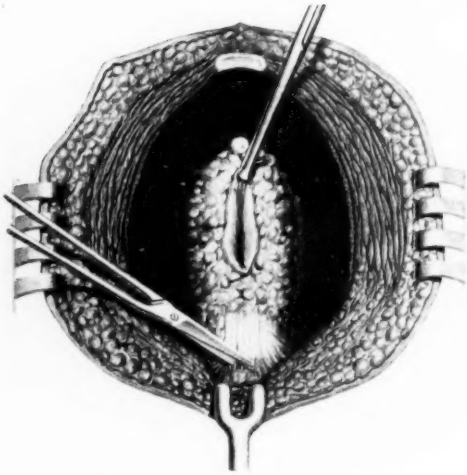

Fig. 3. Division of recto-urethralis muscle.

of 3 or 4 weeks may with benefit be allowed. In the average case 2 weeks is the rule. During this period the bowel above the colostomy is well cleared out and the lower segment, containing the growth, is washed out and rendered as clean as possible. A marked improvement in the patient's general condition results. As repeated observations had shown us that the infection following the second operation was a mixed one, and almost invariably was due to a streptococcus and bacillus coli, we have now for 14 years taken advantage of the interval to give preliminary inoculations of streptococcal and bacillus coli vaccines in doses of ten million of the former and fifty million of the latter, on two occasions, namely 10 days and 3 days before the second operation. The value of this treatment we have shown experimentally to be enhanced by giving 3 cubic centimeters of 5 per cent nucleic acid subcutaneously the night before operation to induce a leucocytosis (the average leucocystosis thus induced is 11,000). We believe that the resistive powers of the patient are thus mobilized before infection has gained a footing.

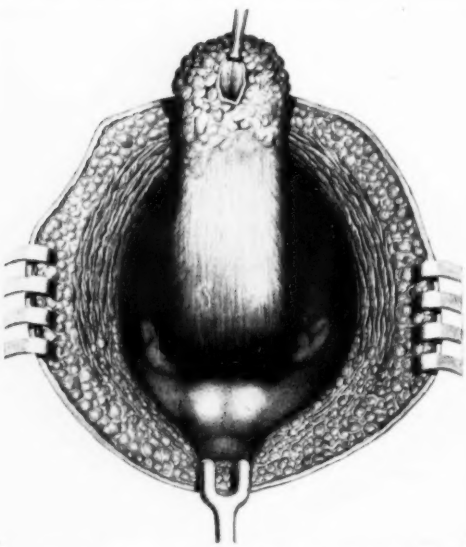

Fig. 4. Prostate exposed and space of Denonvilliers opened.

RADICAL OPERATION

Two hours before operation, morphia ¼ grain and scopolamine 1/100 grain is given; one hour before operation, morphia 1/6 grain and scopolamine 1/200 grain is given. When brought to the theater, the patient is in a deep sleep and does not awake when, through a lumbar puncture, 0.7 cubic centimeter of 10 per cent stovaine (Billon) is administered. For 7 minutes thereafter the patient is allowed to rest in the recumbent position and, in the male, a rubber catheter is meanwhile introduced *per urethram* and stitched in position. The patient is now turned over into the prone inverted V position with the head and feet

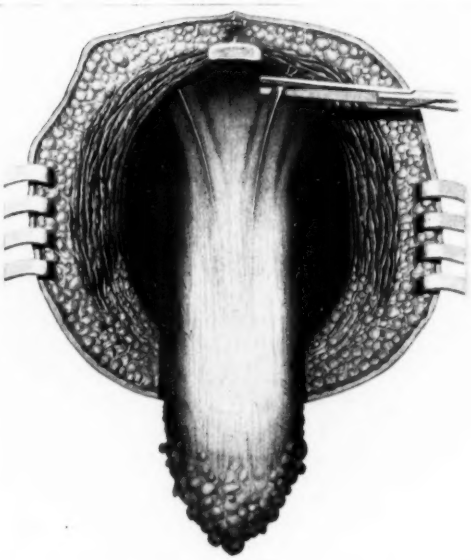

Fig. 5. Division of sling ligaments of the rectum.

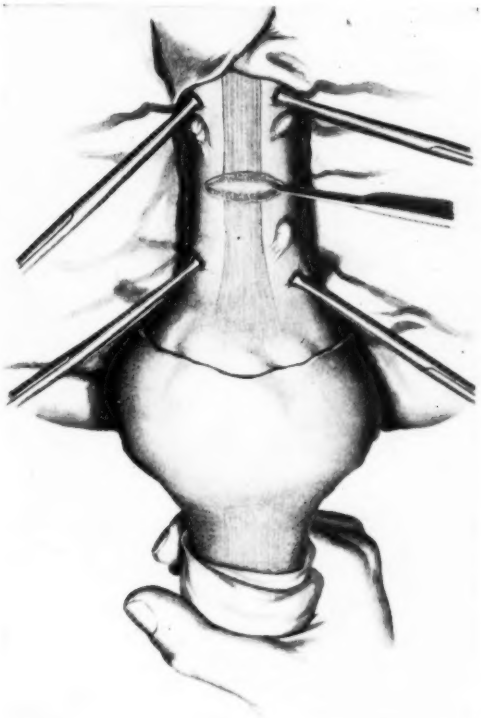

Fig. 6. Pelvic colon steadied by peritoneal forceps while peritoneal and muscular coats are divided round the whole circumference by a sharp knife.

low and the buttocks uppermost (Fig. 1). This position has certain advantages, viz., the field of operation is the highest point in the body and is relatively bloodless; the operator stands over the field of operation, a position to which he is accustomed; with spinal anæsthesia the head-low position is that associated with fewest after symptoms.

STEPS OF OPERATION

1. The *anus* is closed by an encircling silk suture.

2. An *elliptical incision*, encircling the anus and removing three-quarters of an inch of skin around it, is carried upward to the sacrococcygeal joint and forward to the mid point of the perineum.

3. The structures attached to the coccyx, namely the gluteus maximus and external sphincter, and in front of these, the levator ani and the coccygeus muscles and portions of the sacrosciatic ligament, are severed and the *coccyx disarticulated* by pressing its tip forward and entering its joint with the sacrum from behind.

4. Two fingers can now be passed readily up into the hollow of the sacrum, and working from behind forward, the *ischiorectal fat* on either side is severed at its outer limit, and the inferior hæmorrhoidal vessels are secured and ligated.

5. The *levator ani muscle* on each side is now divided from behind forward by the insertion of a finger of the left hand deep to the muscle and division with scissors as near as possible to its pelvic attachment (Fig. 2).

6. The *recto-urethralis muscle* must now be divided. This muscle, which represents the most anterior fibers of the levatores ani, serves to connect the rectum to the membranous urethra, and the accurate division of it constitutes an important stage of the operation (Fig. 3). The tendency is to cut too near the urethra in an effort to avoid a wound of the rectum, and this may lead either to a wound of the urethra or to entrance into the sheath of the prostate instead of the opening up of the space of Denonvilliers. After division of the recto-urethralis the finger can be passed upward readily between the prostate and the rectum (Fig. 4), unless in low seated growths which infiltrate the prostatic sheath. In the case of the latter, the sheath and a portion of prostate may be sacrificed without untoward results.

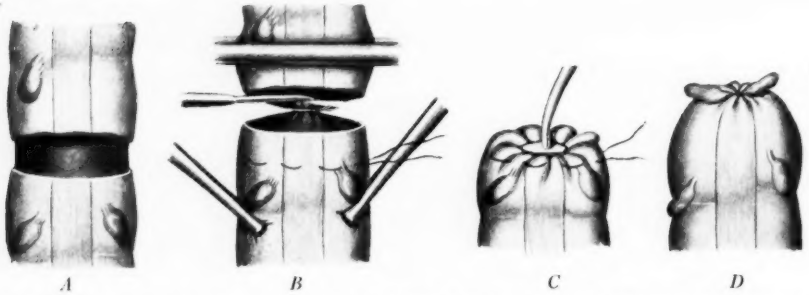

Fig. 7. *A*, Peritoneal and muscular coats divided; *B*, tube of mucous and submucous coats ligated, purse-string suture inserted, clamp applied to distal portion, and cuff being divided by carbolized knife; *C*, invagination of the stump; and *D*, invagination complete.

7. The *sling ligaments*, or fascial bands containing the middle hæmorrhoidal vessels, can now be easily felt on either side preventing further delivery of the rectum. They must be secured in forceps as high up as possible, cut and ligated (Fig. 5).

8. The *peritoneum* is opened and divided well round to either side of the rectum. It will always be found that division of the lateral reflections of the peritoneum allows the rectum to come down freely.

9. The lowest part of the pelvic colon can now be grasped and brought down, and the further descent of the rectum is impeded merely by its vascular pedicle containing the superior hæmorrhoidal vessels. It is desirable to ligate these vessels as high up as possible, and it is often an advantage to divide the bowel and invaginate the upper end before the vascular pedicle is tackled.

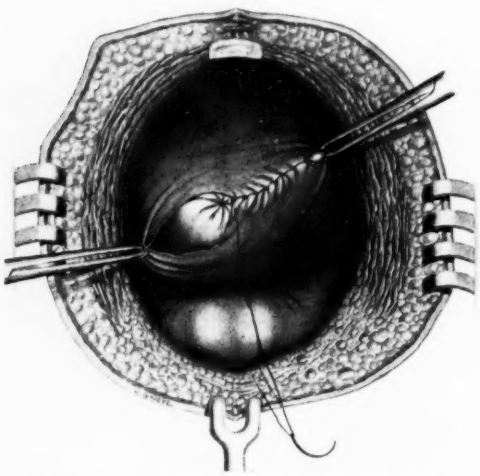

Fig. 8. Closure of peritoneum. Stump being caught up and fixed in the line of suture.

10. *Division and invagination of the colon* may be greatly simplified by the adoption of the cuff method (Fig. 6). The site for division, which must be at least 2 inches above the upper limit of the growth, is put on the stretch, and with a sharp knife the peritoneum and muscular coats are divided all around leaving a relatively slender tube of submucous and mucous coats (Fig. 7). A catgut or fine linen purse-string suture is inserted in the bowel three-quarters of an inch above the cuff, and then a strong catgut ligature (No. 2) is tied round the denuded portion. A light clamp is applied distal to the ligature and the bowel cut through with a carbolized knife or the cautery. The bowel proximal to the purse-string suture is then steadied with two Allis forceps, the stump invaginated, and the suture tied. By the use of this cuff method all difficulties with subperitoneal fat and hypertrophied and œdematous muscle, which may be considerable, are avoided, and a stump devoid of tension, and therefore adequately supplied with blood, results.

11. *The ligation of the vascular pedicle*, containing the superior hæmorrhoidals, is now effected and this can frequently be done almost 2 inches higher than the division of the bowel. As this is the most important route of lymph spread it represents perhaps the most vital step in the operation. It is best done by the passing and tying of the ligature without the application of any forceps or clamp.

12. *The closure of the peritoneum* of the pelvic floor by a continuous catgut suture, which fixes the colon stump in the suture line, completes the operation (Fig. 8).

The cavity left is a large one and, in the male especially, there is no means of obliterating it. In

many cases it must inevitably be mildly infected from the number of severed lymphatics running from an ulcerated area. *It is wiser, therefore, to drain freely* by means of a large tampon of gauze covered by perforated oiled silk. One or two fishing-gut sutures are inserted at the extremities of the wound, the major portion of which is left open.

AFTER-TREATMENT

The patient is put back to bed with the foot of the bed raised one foot and is left in this position for 12 hours. This prevents postoperative headache, probably by precluding the seepage of cerebrospinal fluid from the lumbar puncture. At the end of 12 hours the head of the bed is raised to allow of descent of the pelvic floor, and thus a diminution in the size of the cavity left by operation. The packing is removed at the end of 48 hours, and daily thereafter the wound is irrigated with weak eusol solution and lightly packed. On an average 7 weeks are required for the healing of the wound. Passage of a catheter is almost always required for several days. The bladder should not be allowed to become distended or a cystitis will inevitably follow catheterization. Urinary infection is one of the most troublesome complications of the operation and, in a few cases, it may actually threaten life. While some surgeons advocate the tying in of a catheter for several days after operation, special precautions being taken to prevent infection along the catheter, we have preferred to rely on repeated catheterization. Where, prior to the operation, there has been urinary difficulty from enlargement of the prostate, the establishment of suprapubic drainage by means of a Pezzar catheter should be considered. We have carried out this method in two cases and we have found that it certainly gives great comfort.

Shock is absent after the operation described above. A certain amount of infection of the wound is usually found. This gives rise to no anxiety and serves a useful purpose in that the inflammatory reaction tends to kill off any outlying malignant cells which may have escaped removal, and it also seals the lymphatics by the fibrosis which inevitably follows.

The patient should be out of bed on from the tenth to the fifteenth day, except in elderly subjects. For the colostomy some form of cap is fitted and the patient is encouraged, by experimenting with his diet, to find one which will result in a soft solid motion *without the use of any aperients*.

RECURRING INTUSSUSCEPTION CAUSED BY INTESTINAL NEOPLASMS, REQUIRING MULTIPLE OPERATIONS FOR ITS RELIEF

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AND
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INTUSSUSCEPTION in adults or indeed at any age after 5 years differs considerably from the disease as it occurs in infancy and early childhood, not only in its clinical aspects but especially in its etiology. No constant pathological condition has been found to explain its frequency in the early years of life, whereas in later life statistics show that in the overwhelming majority of instances a tumor, or more rarely some other localized lesion of the intestinal wall, is present and must be assumed to be the underlying cause. This fact is well known to students of the subject, but most surgeons encounter but rarely intussusception in the adult, and ignorance of the presumptive etiology leads to failure to cure rather than temporarily to relieve the condition, and results in multiple operations which might have been avoided. A case is here reported which illustrates this fact, and is added to 12 similar ones found in the literature.

The patient (Surg. No. 24053), a married Syrian woman 22 years of age, was first admitted to the Peter Bent Brigham Hospital on June 10, 1925, complaining of cramp-like abdominal pains. Her general health had been excellent until 1920 when she became constipated and began to have severe attacks of vague colic-like pain in the lower abdomen. Shortly afterward she immigrated to this country and as her symptoms continued she suffered the loss of her appendix, her tonsils, and the fixation of her right kidney. In spite of these efforts the attacks came with increasing frequency and included nausea and vomiting. She lost 40 pounds in weight. Examination was essentially negative except for evidence of malnutrition and a visceroptotic posture. Palpation of the abdomen showed vague, inconstant masses which were thought to be due to fæcal retention. Repeated stool examinations were negative. Barium gastro-intestinal studies showed no evidence of any intrinsic pathological lesion but confirmed the impression of visceroptosis. An abdominal support was prescribed and she was discharged with the diagnosis of visceroptosis.

She was admitted a second time (Surg. No. 25492) on January 1, 1926, having been followed in the Out-Door Department and instructed as to her general hygiene and diet. She had been wearing a satisfactory abdominal support. These measures were unexpectedly effective and the attacks had diminished and finally had practically ceased. She gained weight and her constipation was relieved. A few hours before admission she had a sudden severe pain in the left lower quadrant, vomited several times, and had several loose stools which contained no gross blood. Examination showed a definite mass in the left lower quadrant associated with visible peristalsis, but on palpation the mass disappeared only to reappear a few hours later in the right lower quadrant. She was operated on as an emergency by the resident surgeon, who found an intussusception of the ileum which was easily reduced. The bowel rapidly regained its normal tone and appearance. There was no evidence of thrombosis of the mesenteric vessels and there seemed to be no indication for resection. No tumor was noted. Her convalescence was uneventful except that on the seventh, twelfth, and twenty-second days she had slight similar attacks which soon terminated spontaneously. She was discharged with advice as to measures intended to correct her tendency to visceroptosis.

The patient was admitted for the third time (Surg. No. 26626) on June 25, 1927, a year and a half later. Again she had had a long interval of comparative comfort. She had gained a good deal of weight and her general condition had improved. Again a sudden attack of pain and vomiting had occurred and on examination a vague, doughy mass with visible peristalsis was noted in the left lower quadrant only to disappear and reappear later on the right. It was thought that she was the victim of a perverted peristalsis causing multiple slight invaginations of the bowel at different places. Once more the symptoms and objective signs rapidly cleared up and once more she was discharged.

Her fourth admission (Surg. No. 29663) occurred 3 months later on September 16, 1927. She had been practically free from symptoms during the interval until they recurred 6 days before entry. Examination on this occasion was negative except for moderate abdominal distention, but during the next few days of observation she had two attacks in which a mass could be palpated in the abdomen. A recurring incomplete strangulation due to adhesions was considered the most probable explanation. At operation on September 29, 1927, an intussusception forming a mass 32 centimeters long and 7 centimeters in mean diameter was found at about the mid point of the jejuno-ileum. Reduction was impossible and a resection with end-to-end anastomosis was performed. Her surgical convalescence was uneventful and in the succeeding 10 months there has been no return of her symptoms. Examination by the pathologist showed that at the apex of the intussusceptum was a small lipoma springing from the mucous membrane.

A search of the literature discloses 10 similar cases which are briefly abstracted:

CASE 1. Reported by Connors. A man, age not stated, came under observation with symptoms of obstruction. At operation an intussusception of the ileum was found about 2 feet from the ileocæcal valve. After reduction, a tumor was found and the bowel resected. Pathological examination showed round-cell sarcoma. Eight months later the patient returned with the same symptoms and at a second operation an exactly similar condition was found about 3 feet from the site of the previous resection. Again the intussusception was reduced, a second tumor found, and

the intestine resected. The patient made a recovery and was well 3 months later.

CASE 2. Reported by Hartshorn. A man without premonitory symptoms suddenly developed an attack of intestinal obstruction with tenderness in the right lower quadrant. At operation an ileocæcal intussusception was found. It was easily reduced. No tumor was noted. On the tenth postoperative day, symptoms recurred and at operation evidence was thought to be found of obstruction due to adhesions. On this occasion, however, a tumor overlooked at the previous operation was found in the ileum 18 centimeters from the ileocæcal valve. It may be presumed that the second attack was in reality due to a recurrent intussusception, which was spontaneously reduced. The tumor proved to be a fibroma.

CASE 3. Reported by Collier. A woman of 26 years had had attacks of abdominal pain and vomiting at intervals of 2 months. At operation a small adenoma of the ileum 20 centimeters from the cæcum was found and removed. Two months later the symptoms recurred, and at the second operation an intussusception 15 centimeters proximal to the site of the old operation was found. It was easily reduced. A few days later the same symptoms recurred but operation was refused until 6 months later when, after marked loss of weight and persistence of obstructive symptoms, an operation was done, when a pedunculated tumor of the jejunum was found and 20 centimeters above this an intussusception. Both tumor and intussusception were resected and the patient recovered.

CASE 4. Reported by Wardill. A man of 43 years gave a history of intermittent attacks of abdominal pain for 7 months and fresh blood in the stool the day before admission. Symptoms pointed to partial obstruction. At operation an intussusception of the descending colon was found which was easily reduced. No tumor was found at the point of the intussusception, but 5 inches proximal there was a small, firm carcinoma. Three weeks later the abdomen was reopened for the purpose of removing the growth and it was found that the intussusception had recurred and the tumor was then at the apex of the intussusceptum. It was resected and recovery ensued.

CASE 5. Reported by Barrington. A girl 6 years of age gave a history of attacks of abdominal pain and vomiting for 2 years. Examination showed a palpable abdominal tumor; laparotomy disclosed an intussusception of the jejunum which was easily reduced, with recovery. No tumor was noted. Two weeks later the symptoms recurred and at a second operation another intussusception was found at the same site which was again easily reduced. On this occasion lesions which appeared to be tubercles were noted on the peritoneal surface. The symptoms recurred irregularly and 10 months later a third operation was done revealing an intussusception of the jejunum at no less than 3 separate points. Again reduction was accomplished and the bowel carefully examined but no definite tumor felt. On 2 occasions during convalescence a recurring intussusception was reduced by manipulation through the abdominal wall. One month later a fourth operation was necessary when an intussusception was again found and reduced. "On careful examination it was then possible to feel distinctly two groups of tumors in the bowel some 6 inches apart and it was evident that these were the cause of the intussusception." A resection was done and the patient recovered. Pathological diagnosis: adenopapilloma.

CASE 6. Reported by Lee. A woman 40 years of age gave a story of recurring attacks of pain in the right lower quadrant. At the first operation the appendix was removed and found to be normal. Symptoms continued and 2 months later assumed the character of obstruction. At a second operation a double intussusception of the ileum

Fig. 1. Portion of ileum resected (Surg. No. 24053) showing *A*, tumor; *B*, intussusceptum; and *C*, intussuscipiens.

was found which was easily reduced, with recovery. Three weeks later the symptoms recurred and at a third operation an intussusception identical with the previous one was discovered. It was reduced and a tumor was felt within the bowel. The intestine was resected and the patient recovered. Pathological diagnosis: fibroblastoma.

CASE 7. Reported by Graham. A boy about 14 years of age gave a history of cramp-like abdominal pain for 6 weeks. At operation an ileocæcal intussusception was found and easily reduced. Subsequently attacks of pain and vomiting continued and 5 weeks later a second operation was done and the ileocæcal intussusception was again found. Reduction was impossible on this occasion and the bowel was resected and showed on examination a round-cell sarcoma of the terminal ileum. Patient recovered.

CASE 8. Reported by Watts. A man 24 years of age gave a history of cramp-like abdominal pain and occasional vomiting for 3 years and entered the hospital with symptoms of acute obstruction with visible peristalsis and a palpable mass. At operation an intussusception of the lower ileum was found and easily reduced. Two pedunculated tumors were palpated within the intestine, but removal was not attempted at this time. The symptoms recurred one week later and at a second operation a similar intussusception was found and was with difficulty reduced. The intestine was resected and the patient recovered but had an intestinal fistula for some months. At a third operation, a pedunculated tumor was found in the sigmoid which was resected. Examination of the rest of the intestines showed numerous, small, pedunculated tumors. A lateral anastomosis was done around one which seemed to be producing an invagination. The patient recovered. Three months later a fourth operation was necessary at which 7 pedunculated tumors were removed and another lateral anastomosis performed. The patient recovered and was well 4 months later.

CASE 9. Reported by Cope. A man 21 years of age gave a long story of attacks of violent abdominal pain for which appendicectomy was done without relief; at a subsequent attack visible peristalsis was detected and at a second operation adhesions were found which were thought to be the cause of the obstruction, and were freed. One week later, on account of recurrence of symptoms, a third operation was done and an intussusception of the jejuno-ileum at about its mid-portion was found and reduced. Search

was made at this time for a tumor and some soft lumps were felt in the bowel in that portion which had formed the apex of the intussusception. These lumps were soft and appeared movable and it was concluded that they were fæcal masses. On the thirteenth day after the operation acute symptoms again supervened. The abdomen was again opened and an intussusception identical with the previous one was found and reduced. Intra-intestinal masses were palpated as before. The bowel was incised over one of them and a pedunculated papilloma removed. Further operation seemed contra-indicated at the time and 6 days later the abdomen was again opened and two more papillomata were removed. The patient recovered.

CASE 10. Briefly mentioned by Richardson in a discussion of a paper on intussusception by J. S. Stone. One patient who had recurring intussusception at the Massachusetts General Hospital, "had a tumor and recovered after resection at the second operation", implying that the tumor had been overlooked at the first. Mention was also made of another patient who "died of the third intussusception and the tumor was never removed."

CASE 11. Reported by Quénu. A man 32 years of age gave a history of having been a sickly baby subject to constipation. At 5 years of age he had had his first severe attack with distention and occasional bloody diarrhœa. At operation an intussusception of the ileum was found and readily reduced. Seven days later the symptoms recurred and at operation the intussusception was again found. A resection was necessary and when the specimen was opened an adenoma the size of a walnut was found. This had been missed at the first operation due to the thickened and indurated bowel wall. The patient died on the eighth postoperative day.

CASE 12. Reported by Van Dijk and Oudendal. A young man 16 years of age gave a typical history of recurring intussusception. Roentgenograms after a barium meal were negative. At operation an intussusception of the ileum was found and, although it was easily reduced, an adenoma "the size of a cherry" was palpated at the apex of the intussusception which was resected. He made a good recovery but 6 months later his symptoms returned and at the second operation a similar intussusception was found above the previous anastomosis and several adenomata were palpated and resected. The patient recovered. It is interesting that this patient's sister had a similar story, and at operation an intussusception caused by an adenoma was found and resected. She also recovered.

These 13 cases may be divided into 4 groups on the bases of treatment given and the failure of the surgeon to recognize the complete pathology.

Group 1. At the first operation the intussusception was found and reduced but the tumor which caused it was overlooked, thus necessitating a second operation for its removal. This happened in 8 instances.

Group 2. At the first operation an intussusception was reduced and the tumor resected, but a second tumor was overlooked which later caused another intussusception and required a second operation for resection.

Group 3. At the first operation a tumor not accompanied by intussusception was found and resected; at a second operation an intussusception was reduced but the causative tumor overlooked; a third operation was necessary to resect the second tumor when it caused a recurring intussusception.

Group 4. At the first operation an intussusception was reduced and the causative tumor was found but was not removed; at a second operation a recurring intussusception was resected with the tumor; at third and fourth operations multiple tumors were removed or excluded.

It is clear that to a greater or lesser degree in these reported cases there was a failure on the part of the surgeon to understand clearly the relationship between tumor and intussusception In one instance it was only after an intussusception had been reduced three times by laparotomy and twice by manipulation through the abdominal wall that at a fourth operation the true relation between tumor and intussusception was realized and a cure of both conditions was accomplished by resection.

The cause of intussusception has long intrigued the interest of clinical investigators. Three underlying factors have been proposed: (1) perverted peristalsis; (2) paralytic conditions of the bowel allowing prolapse; (3) a lesion of the intestinal wall, whether or not causing partial obstruction, such as a tumor, a diverticulum, an ulcer, or an inflammatory thickening.

The first two suggestions are vague and unsupported by satisfactory evidence. As Wardill remarks: "the bowel is expected to display suicidal tendencies for no apparent reason." It is true that at laparotomy under local anæsthesia, or in the experimental animal, transient slight invaginations of the bowel are often noticed; and also that similar conditions are found at autopsy, but there is nothing to prove that these conditions are other than transient or agonal. On the other hand, the third theory is abundantly supported by evidence from the literature. Kassemeyer states that in 284 cases of intussusception in adults, tumors were present in 208, and appendices or diverticula were found in the remaining 76. Clifton and Landry, tabulating 45 instances of fibromata of the intestine, say that in 31 patients in whom the tumor was present in the lumen of the intestine, intussusception was present in 29. Eliot and Corscaden say that of 300 cases of intussusception in adults, 100 were associated with neoplasma and many others with ulcers, or foreign bodies, and inasmuch as tumors are so frequently overlooked, it is probable that the proportion is much greater. Cases are reported of invagination of a Meckel's diverticulum causing intussusception (Lower) or a typhoid ulcer or a local thickening due to tuber-

culosis. The tumor or other lesion is almost invariably at the apex of the intussusceptum. The mechanism probably represents the reaction of the intestine to the tumor as a foreign body which it attempts to expel. A pedunculated tumor may be pictured as lying with its free extremity swept caudad with the fæcal current. A peristaltic wave approaches it from the cephalic direction and pushes it into the relaxed intestine beyond, where it is gripped by successive rings of contraction which push it onward while the intestine, now relaxed at the point of attachment is drawn after it, permitting the growth of the invagination at the expense of the intussuscipiens. It is not difficult to picture the same process in the case of a massive ulcer or other mural infiltration. It must be admitted, however, that in the presence of a tumor, the intussusception sometimes may be at some little distance either proximal or distal, suggesting that the new-growth has caused to appear in its neighborhood an anomalous type of peristalsis. Collier, in reporting a remarkable case of this sort, says: "There is no doubt that this woman had two adenomata and two intussusceptions along her intestine at the same time, in order from above downward as follows; intussusception, adenoma, intussusception, adenoma."

Objection will be at once raised that while the etiological factors suggested may account for intussusception in adults, they are absent in the vastly more numerous instances in infancy and childhood. It is well known that the lesion is more common in the first 2 years than in all subsequent years of life taken together, and that it occurs as an invagination of the terminal ileum into the large bowel, either through the ileocæcal valve or with that structure acting as the apex. No tumor or gross pathological lesion seems to play any part in this process—a fact which tends to discredit the etiological responsibility of these conditions in intussusception in older individuals. Perrin and Lindsay, however, elaborating suggestions made by others, call attention to the enormous development of the lymph follicles in the wall of the terminal ileum and about the ileocæcal valve, which reaches its maximum before the age of 2, and which is doubtless augmented in bulk by toxic absorption due to disturbances of intestinal digestion so common during the first 2 years of life. Thus the bowel wall at this point may become so massive as to constitute a tumor which may lead to intussusception in the same manner as does a true neoplasm in the adult. If this view is accepted it places the etiology of most cases of intussusception on the same basis.

In a review of the cases noted in this communication it becomes evident that the clinical picture of intussusception in the adult varies considerably from the conventional one which is based chiefly on the symptoms of the disease in infancy. In the adult the attacks are irregularly recurrent, often with long free intervals. The symptoms are often mild, consisting of colic-like pain, nausea, sometimes vomiting, but they may be more acute and characteristic of obstruction. A tumor is frequently not noted, but when present with visible peristalsis, especially if the tumor subsequently disappears, the picture is almost pathognomonic. Gross blood is seldom noticed in the stools. Such rather vague and inconclusive symptoms lead too often to ill-considered operations for the removal of the appendix or fixation of the kidney or some meddling with the pelvic organs. The true diagnosis may be suspected, but cannot be confirmed, because barium X-ray studies cannot be made in the presence of acute symptoms, and in the free intervals the scanty diffusion of the barium in the small bowel does not permit the tumor to be outlined.

SUMMARY

From a study of this group of cases it seems possibly useful to formulate as follows certain suggestions for guidance in a field where the chances of a misstep are considerable.

1. Among the possible causes of irregular attacks of colic-like abdominal pain in adults, without obvious etiology, must be counted recurring intussusception.

2. In patients with such symptoms, to remove a suspected but innocent appearing appendix, or to fix a harmlessly mobile kidney without careful examination of the intestinal tract, is poor surgery.

3. If an intussusception is found and reduced, it is wise to assume that a tumor is present at the apex of the intussusceptum which should be removed.

4. If no tumor is found in connection with the intussusception, search should be made for one a short distance both proximally and distally.

5. If a tumor is found without intussusception the intestine should be examined proximally and distally as another one may be present there.

6. In any case of intussusception due to tumor, the whole intestinal tract should be examined as thoroughly as possible, since tumors are often multiple and may cause recurrent attacks.

Every tumor of the intestinal tract, especially if the tumor is situated within the lumen of the intestine, no matter how benign the character

of the growth, should be removed unless there is definite contra-indication, since it always carries the threat of intussusception.

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ANATOMICAL SURVIVAL, GROWTH AND PHYSIOLOGICAL FUNCTION OF AN EPIPHYSEAL BONE TRANSPLANT

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"IF the epiphysis has been destroyed, the bone will not grow in length from this implant at the point of epiphyseal absence, unless an epiphysis is transplanted. I have not yet demonstrated that a transplanted epiphyseal line of young bone will become osteogenetic. In the next case that presents itself with an absent epiphysis, I shall take the upper or lower end of the tibia with its epiphysis and transplant it, because I feel that in young individuals it should become osteogenetic." This was written in 1912 by that resourceful surgeon John B. Murphy in a discussion of the subject of bone grafting.

One of the instances most liable to end with the destruction of an epiphysis is acute foudroyant osteomyelitis which has not received prompt treatment. With improving medical education, fortunately, such cases are bound to become a rarity. Of course, since 1912 innumerable cases of osteomyelitic destruction of the shaft of bones have been successfully repaired by means of bone transplantation by various surgeons. In the field of bone grafting there is also a small number of cases on record in which entire joints have been transplanted with success. But, in spite of these facts, in the literature available to me, I have not been able to find a case reported of successful transplantation of a piece of diaphysis with the epiphyseal line and a part of the epiphysis attached *in which the epiphysis has survived, grown, and continued to function physiologically.* From this fact I derive the justification to swell the already voluminous literature on bone grafting by the report of a case which, on account of its continuous observation from 1912 to date, has proved extraordinarily interesting and instructive. In passing I may say that the words of the eminent master quoted above furnished to me the stimulus for proceeding as I did in my attempt to re-establish anatomical relationship and function to the leg of the patient.

S. H., at the age of 4½ years, in the beginning of November, 1910, had severe pain in his left leg, and high fever. The case was treated as rheumatism. When I saw the boy first on November 10, there could not be any doubt as to the diagnosis: osteomyelitis acuta. Immediate operation was advised. The pus had in several places already broken through the cortex of the tibial shaft. The medullary cavity was thoroughly and extensively opened. The condition of the patient was very bad, but improved gradually. Within 2 weeks practically the entire lower half of the tibia including the epiphysis became sequestrated. Then the wound started to granulate quickly and on December 21, 1910, the patient was discharged from the hospital with the entire cavity in healthy granulating condition. In another 2 months (February, 1911) the skin had healed.

At that time I had already advised the patient's father that later on probably a bone graft operation would have to be done, but that this would not be possible, until the leg had been free from any recurrent inflammation for a considerable length of time. Meanwhile we confined ourselves to combating the increasing deformity which, on account of the continued growth of the fibula and the retardation of growth of the tibia, finally reached a considerable degree with such inversion of the foot that the patient practically walked on the external malleolus. The X-ray taken on July 3, 1912 (Fig. 1b) shows this quite clearly. The frontal axis of the talus is tilted about 45 degrees with considerable inward rotation of the sagittal axis. The malleolar end of the fibula is about 3 centimeters lower than normal with reference to the talus. The radiogram also shows the result of the osteoblastic activity of the surviving periost. This had at that date come to a stand-still. For all practical purposes we had here reached a final result which from the standpoint of weight bearing was entirely unsatisfactory.

Meanwhile (May, 1912) I had read the above mentioned résumé of Murphy with the suggestion quoted. I decided that the case was an appropriate one for a trial of the method and, after a consultation with the father of the boy, obtained his permission to proceed with the "experiment."

On October 5, 1912, the operation was done. The chief principles considered essential for success were: first, aseptic work; second, careful preparation of the graft bed with the intent of obtaining as good a blood supply as could be had; third, accurate apposition and firm fixation of the graft; fourth, subjection of the epiphyseal line to good physiological pressure (Wolff's law); and fifth, thorough immobilization of the ankle for a considerable length of time.

Operation. An incision was made about 12 centimeters long anterior to the old scar. The soft parts were lifted up *en masse* on both sides and all scar tissue in the neighborhood of the graft bed was thoroughly excised. The main spur of the tibia (Fig. 1b) was preserved, while most of the bone situated medially was removed. The idea was to cut a good notch into the tibia for reception of the upper end of the graft and to vivify the remaining lower part of the tibial spur, in order to obtain good lateral apposition for most of the length of the transplant (Fig. 3). In the process of preparing the graft bed in the lower part of the wound, the greater part of the upper surface, the trochlea, of the talus became exposed. The distance from the notch cut into the tibia to the talus was 10 centimeters.

Then a transplant was taken from the right tibia (Fig. 2) including the epiphyseal line and the internal malleolus. The piece was 13 centimeters long and was removed with blade, saw, and chisel in the fashion indicated in Figure 3. The periosteum was carefully preserved and some of the

medullary spongiosa was left attached to the cortex. Without delay, the transplant was fixed firmly in the bed prepared by means of a silver wire encircling the lateral spur of the tibia, the graft, and a small preserved piece of the medial regenerated tibia. In this process the talus was pressed down by forceful eversion of the foot. The graft acted as a brace after release of that force. The result was a correction of the frontal axis to about 20 degrees and a lengthening of the leg of nearly 3 centimeters (Fig. 4). After this the wound was sutured and a plaster cast applied, reaching to the knee and embracing the foot.

The further course of the case is best reported by a series of X-rays taken from time to time.

Figure 1a. The X-ray film taken on July 3, 1912, shows the upper part of the tibia and the osteomyelitic destruction which begins about 6 centimeters below the knee joint reducing the tibial shaft to nearly half its normal diameter. The picture also shows the degree of final regeneration after 20 months.

Figure 1b. Radiogram of July 3, 1912, shows the lower end of the tibia badly deficient as regards regeneration. There is a well developed lateral and a poorly regenerated medial spur. The epiphysis is gone and the internal malleolus is only spuriously present. The talus is pushed up about 3 centimeters and its frontal axis forms an angle of about 30 degrees which on weight bearing is increased to 45 degrees so that the external malleolus touches the ground on walking. The foot is inverted and inward rotated.

Figure 2. This picture was taken 6 weeks after the operation November 13, 1912, and shows the area on the right tibia from which the graft was taken. It extends through the epiphyseal line and includes the anterior part of the malleolus internus. An X-ray picture of the left leg taken at the same time was unsatisfactory on account of a heavy plaster cast and a poor X-ray outfit.

Figure 3. This is a diagrammatic sketch of the extent of the graft taken from the right tibia. Its length was 10 centimeters. The cross section is projected onto the tibiofibular surface of the ankle joint.

Figure 4. The first successful radiogram taken of the operative area, December 18, 1912, shows the immediate result of the operation. The graft rests securely in the notch cut into the tibia. The surrounding silver wire holds it firmly in accurate apposition to the tibial spurs. The talus has been pushed down with reference to the fibula (see Fig. 1b). Its upper surface approaches much more the horizontal. The joint line is distinctly visible. The small area of bone to the left and above the epiphyseal line of the graft which is held to the transplant by the wire is an area of periosteal regenerated bone and corresponds to the former internal malleolus. The X-ray picture shows two views taken from different angles. There is so far very little change and only perhaps a slight amount of knitting to be noted in the graft. Immediately above its epiphyseal line there seems to be a small area of absorption.

Figure 5. The radiogram of January 20, 1913, shows the beginning repair of the bone from which the graft was taken. The transplant begins to form union with the tibia at its upper end. The diaphysis of the graft shows little change, while the epiphysis is increasing in volume. There is a decided lateral expansion and also some growth in the vertical diameter. The talus is being pushed down by the growth of the epiphysis (see Fig. 4) and its frontal axis approaches the horizontal more and more. The epiphyseal line of the transplant broadens and medially one notices the formation of a malleolar-like projection of the graft epiphysis.

Figure 6. The X-ray film of March 31, 1913, shows a still greater enlargement of the epiphysis with heavy areas of calcification. The epiphyseal line of the transplant is distinctly discernible. It exhibits some irregularities. Union of the diaphysis of the graft proceeds normally along the entire tibial spur.

Figure 7. In the radiogram of April 5, 1913—6 months after operation—the right leg still shows clearly the area from which the transplant was taken, although in its upper end there is strong tendency toward obliteration. The graft shows further growth and more homogeneous calcification of the epiphysis. The epiphyseal line is gradually disappearing. The diaphysis of the transplant becomes thicker, while its union with the tibia is almost complete. On the medial small piece of tibia, one notices osteoplastic activity tending toward union with the diaphysis of the tibia and the transplant.

Figure 8. The picture was taken on May 7, 1913. The striking feature here is the tendency of the transplant to grow in a downward direction. Its lower end now has reached a level somewhat below the epiphyseal line of the fibula. The medial piece of tibia shows further osteoplastic activity and inclination to unite with the graft. The volume of bone surrounded by the wire increases as evidenced by the sinking in of the wire into the bone substance.

Figure 9. The X-ray picture of October 22, 1913—1 year after the operation—shows the diaphysis of the tibia fairly well re-established. The various components—lateral tibial spur, diaphysis of the graft, and medial periosteal osteoplastic formation—are forming one solid mass of bone. The epiphyseal line of the transplant is still visible and shows considerable broadening out. The epiphysis now forms a large mass projecting over the epiphyseal line on both sides. It appears, however, to contain various areas of absorption. The remainder of the original malleolus internus shows little, if any, part in the process of re-adjustment (see Fig. 4).

Figure 10. This radiogram was taken on August 12, 1914, or nearly 2 years after the operation. At that time the patient had walked normally for months. The wire had gradually become imbedded in the bone. The epiphysis has grown to a size far above the normal and has pushed the talus down so that its frontal axis is practically horizontal. The ankle joint is distinctly visible and functions normally. Normal weight bearing is established. The joint line is in normal relationship to the external malleolus. The newly formed mass of epiphyseal bone still shows various areas of absorption, especially along the epiphyseal line of the transplant.

Figure 11. The last X-ray picture taken on May 26, 1928, or 16 years after the operation, shows the complete consolidation of the tibial area and the persistence of the epiphysis. The silver wire is entirely surrounded by bone. The epiphyseal line is still slightly indicated; but the bone trabeculæ of the tibia are seen to continue in their course through the epiphyseal line into the epiphysis, which now forms a large mass of bone, the fibula lying in a groove of that mass. The ankle joint is plainly seen. It is freely movable, although the extent of motion is somewhat limited.

So much about the progress of the case as revealed by the radiographic study. A few photographs will supplement the picture.

Figure 12 is a photograph taken on September 15, 1914, of the boy at the age of 8½ or nearly 2 years after the operation. The patient at that time had walked for about 8 months. There is some shortening—4.5 centimeters—of the left tibia. The distance from the lower margin of the patella to the tip of the external malleolus is 34.5 centimeters on right and 30 centimeters on left side. The left patella points straight forward, while the foot

Fig. 1a.

Fig. 1 b.

Fig. 2.

is abducted about 45 degrees. There is a slight degree of pes calcaneocavus and some atrophy of the entire left extremity. But motion and function are good.

Figures 13 and 14 show the condition described in Figure 12 more in detail.

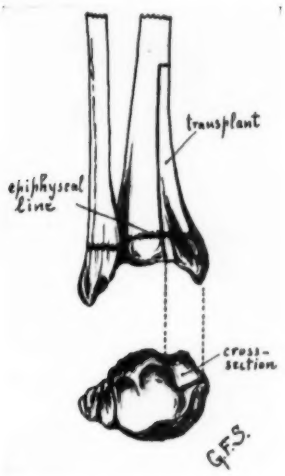

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Figure 15 is a photograph taken on September 3, 1928, or 16 years after the operation. The patient is now working in the building trade. The function of the left leg is excellent. There is no pain or discomfort. The motion is good, although somewhat limited as far as flexion and extension of the ankle joint are concerned. The abduction of the foot with reference to the position of the patella is about 30 or 15 degrees less than 14 years ago. The tibia has kept on growing. The distance from the lower margin of the patella is 48 centimeters on the right and 43 centimeters on the left side. In other words, there is a difference of 5 centimeters as compared with 4.5 centimeters in 1914. The foot still is of a slight calcaneocavus type, although less so than 14 years before.

We have here a case of transplantation of a piece of bone including shaft, epiphyseal line, and epiphysis which has been successful in so far as survival, growth, and function of the epiphysis is concerned. After 16 years and the completion of growth of the individual the present state, in

Fig. 8. Fig. 9. Fig. 10. Fig. 11.

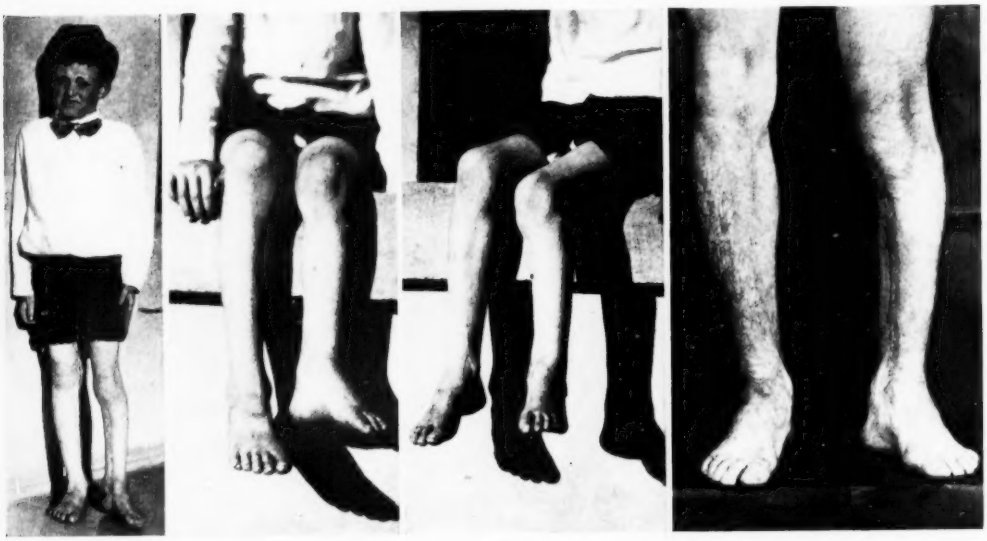

Fig. 12. Fig. 13. Fig. 14. Fig. 15.

my opinion, must be looked at as definite and final. I have the impression that the mechanical factors, subjecting the epiphysis to a considerable physiological amount of pressure and the early weight bearing after consolidation of the graft with the tibia, were of considerable importance for the subsequent development of the epiphysis. In other words, the practical application of Wolff's law furnished the basis for its growth and function along physiological lines. J. B. Murphy was right when he thought that an epiphyseal graft "in young individuals should become osteogenetic."

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TORTICOLLIS; REMOVAL IN EARLY LIFE OF THE FIBROUS MASS FROM THE STERNOMASTOID MUSCLE

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THE etiology of congenital torticollis, so-called, remains controversial. The first attempt at correction of the condition by open section of the sternomastoid muscle seems to have been made in 1641 by Isaac Minnius in Germany. Various theories as to cause have been suggested. The one receiving most support is that of intrauterine position. It is not wholly satisfactory, however, because other muscles in the neck besides the sternomastoid should be more definitely involved with it or at least occasionally affected similarly.

That injury to the sternomastoid muscle during delivery occurs frequently is not denied. Whether the muscle in these cases was contracted before birth and for that reason injured at the time of delivery is not known. Siffel has reported torticollis in four patients in whom prenatal X-ray films showed a crowded position of the head. If the muscle had been contracted *in utero*, it would seem that uninjured muscles of this type would appear more frequently. The theories advanced for such incidence include abnormal position resulting in ischæmia from involvement of the superior thyroid artery; infection; excessive nervous stimulation; and an anomaly in the muscle blastema itself. Again it would seem that other muscles in the neck and elsewhere might occasionally show such lesions, and that there should be more postpartum evidence to corroborate these theories.

Denial has been made that a ruptured or torn muscle, specifically the sternomastoid, contracts. There is evidence at the New York Orthopædic Dispensary and Hospital, and also from other clinics, that contracture does take place, though not always. That this phenomenon has not been noted in other muscles may be accounted for by the age and activity of the patient and by the fact that few other muscles are isolated anatomically to the same degree. The sternomastoid is isolated by its oblique and superficial position and by an unusually firm sheath throughout its entire length and circumference. The muscle is comparatively long and narrow. A scar in it, especially in an infant, might therefore produce a much more extensive contracture than would ordinarily be expected. The fact that injury does not always produce a contracted scar is perhaps explained by the extent of the injury and the physiological conditions of repair. Not all scars in the skin develop a keloid.

The following cases are reported to show the actual conditions encountered in 4 infants having torticollis who were operated upon for the removal of masses from the sternomastoid muscle, and to show the result of this removal. None of these cases was responding to the treatment of massage and manipulation usually relied on for infants.

CASE 1. F. K., N. Y. O. D. & H. No. 93231, July, 1926. The patient, a female, was brought to the hospital when she was 5 weeks old. A history was given of a breech presentation and difficult delivery. A lump in the neck was noticed shortly after birth. The child held its head turned to the left and tilted to the right. In the middle of the right sternomastoid was a firm swelling about 1 inch by ¾ inch. Movement of head to the right was very limited.

July 17, 1926. Through a linear incision the mass in the sternomastoid was exposed and found to be a tough, fibrous portion which extended entirely through the muscle and was sharply limited within the sheath. Torn muscle fibers were clearly evident at the upper and lower poles. The mass was removed and no attempt was made to close the gap in the muscle, though the subcutaneous tissues were sutured to the bottom of the wound. No retentive apparatus was applied. Massage was begun in 4 days.

February 9, 1927. Seven months after operation. The scar was well healed. There was no pain or tenderness. The child held her head straight and moved it freely in all directions. Some kind of continuity had apparently been established between the divided ends of the sternomastoid, and the muscle was functioning although it was smaller and firmer than on the opposite side. It was of normal length.

June 3, 1928. Practically 2 years since operation. Movements of the head were perfectly free in all directions. The divided ends of the sternomastoid had connected, up and appeared to be functioning normally. No palpable evidence of fibrous tissue was found in its extent, no facial asymmetry or scoliosis, and the scar was barely visible.

CASE 2. E. L., No. 94358, August, 1926. The patient, a female, was brought to the hospital when 8 weeks old because of a lump noticed in the right side of the neck about 1 month after birth. Delivery had apparently been normal. The head was tilted moderately and movement to the left was sharply limited. A firm swelling was palpated in the middle of the belly of the right sternomastoid muscle.

September 13, 1926. The child was operated upon and the swelling exposed. There was found to be an area of thick scar tissue extending entirely across the muscle and upward and downward through the muscle belly a distance of about 1.5 inches. It was sharply limited to the muscle. A part of the mass, 1.25 inches, was removed. No plaster was applied. The head was held in an overcorrected position as far as possible while the wound was healing. The wound healed well. At the end of 10 days the child herself held her head straighter without support. Massage was not begun for 1 month.

December 7, 1926. Child had full motion of the head in every direction.

[1]Dr. Von Lackum died June 30, 1928.

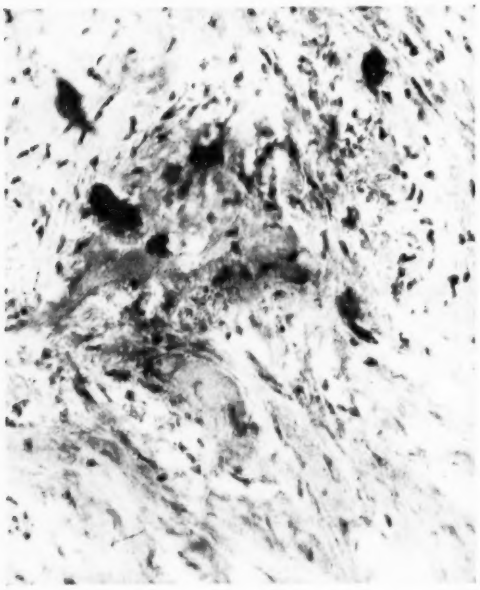

Fig. 1. Case 1. F. K. High power photomicrograph. Degenerating muscle fibers are seen in the midst of a relatively dense scar tissue.

Fig. 2. Case 2. E. L. High power photomicrograph of degenerating muscle fibers cut in longitudinal section, surrounded by scar tissue. The muscle fibers are apparently being replaced by connective tissue.

March 28, 1928. One and one-half years since operation. Movements of head and neck were free in all directions. Sternomastoid was thin but not contracted and was functioning in an apparently normal manner. There was no facial asymmetry or spinal curvature.

Case 3. A. C., No. 94638, September, 1926. The patient, a male, was brought to the hospital at the age of 5 months because he had always held his head tilted to the left. He had been delivered with instruments but no swelling in the neck had been noticed. The head was tilted to the left, with the chin rotated to the right, and there was already some facial asymmetry. There was a mass in the left sternocleidomastoid muscle, with contracture of the muscle.

October 13, 1926. The child was operated upon and the mass exposed. The outer portion of the muscle was apparently normal, but in the middle portion of the medial edge there was a hard, fibrous mass which extended through its entire length. About 1 inch of the mass was removed and the muscle divided across. No apparatus was applied. The wound healed well. Massage was begun after 2 weeks.

December 4, 1926. The scar had contracted a little but there was much freer motion than before operation.

January 6, 1927. Much better; still some contracture.

February 9, 1927. Four months after operation. Patient had no pain but the scar seemed tender. He held his head straight and moved it freely in all directions. Continuity had apparently been established between the divided ends of the muscle and it was functioning actively. It was still somewhat more tense than the opposite muscle.

May 31, 1927. Four months after operation. Massage was discontinued. Movements of head and neck were free.

March 28, 1928. One year 6 months since operation. Movements of head and neck were free in all directions. Facial asymmetry was practically gone. The sternomastoid seemed to be a functioning muscle in its upper half, whereas the lower half was represented by a fibrous band. It was of full length.

Case 4. D. W. L., No. 106201, December, 1927. The patient, a male, was brought to the dispensary at the age of 2 months. The mother gave a history of precipitate delivery of an apparently normal child. At 4 weeks of age a lump was noticed in the right side of the neck. The mother was sure that it was not present before and that the head was not held sideways until it appeared. Examination disclosed a fairly well nourished child of 2 months. The head was held to the right and the chin was rotated to the left. In the middle of the belly of the right sternomastoid was a firm mass, oblong in shape and apparently across the entire muscle and running well up and down.

December 16, 1927. An incision 2.5 inches long was made over the right sternomastoid. The entire lower end of the muscle was dissected free, and running up from both heads of origin into a mass twice as thick as a normal muscle was a fibrous scar. The mass itself was over 1 inch long, and running from it into the upper part of the muscle was a similar scar. Both heads of origin were divided where the scar began and the belly was cut across just below the spinal accessory nerve. The wound was then closed by drawing the subcutaneous tissues into the depths of the gap. No retentive apparatus was used. The head could be moved much more fully immediately after operation.

March 28, 1928. Three months after operation. The scar was indistinct; there was no tendency to contracture.

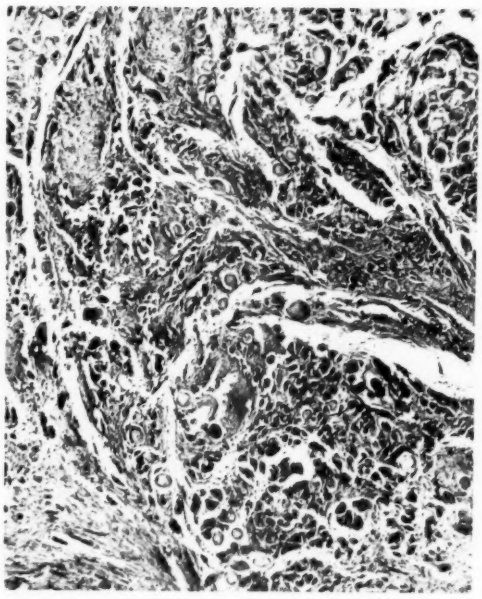

Fig. 3. Case 3. A. C. Low power photomicrograph showing the connective tissue and dense scar tissue which composed the mass removed at operation. Muscle fibers in cross section are seen singly and in groups scattered throughout the picture.

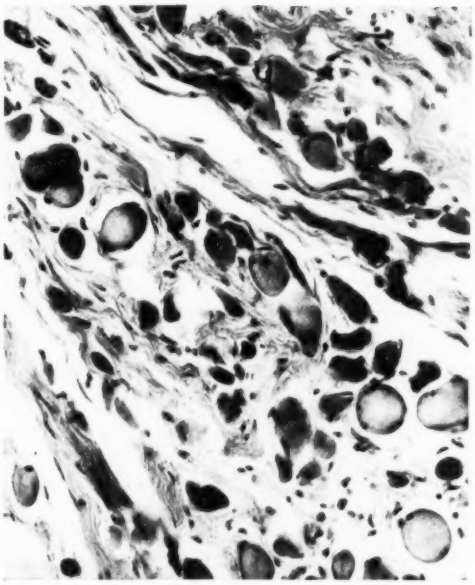

Fig. 4. Case 3. A. C. High power of Figure 3. Note the homogeneous appearance of some muscle fibers and the presence of vacuoles in others indicating degeneration.

The head was held in normal position and was freely movable in all directions.

In going over these cases it will be noted that there was no abnormality of the surrounding musculature of the neck. When the sternomastoid was released, practically full movement was possible. Also, with the exception of one case, the sternomastoid was apparently normal above and below the site of injury, though in the last case reported the scar ran into both divisions of insertion. In the one case, the hæmorrhage or injury had run up and down the entire length of the muscle, but in the outer aspect had left what appeared to be normal muscle tissue. This condition is difficult to account for except by the fact that it was the oldest case and was definitely traumatic. Furthermore, the scarred part, as well as the normal, was limited by a normal appearing sheath. The latter had perhaps been torn with the muscle, but, being fibrous tissue, its repair had left it in good condition. On the other hand, an intact sheath may be the important factor, as by closely confining any hæmorrhage which may have occurred, absorption might be limited and a scar rather than good repair result. In 2 cases the mass was not noticed until a month after birth. This is evidence of contracture of the original traumatic mass, which was perhaps so widespread and soft that it escaped notice.

In all cases muscle tissue was distributed through the mass of scar, becoming more extensive as the muscle was approached at either end or on the side, in the one instance. The fibers in the mass proper were degenerating apparently from pressure. Since operation, except for the slight postoperative scar, the muscle that remains has connected up in one way or another and is functioning in an approximately normal manner. This has been noted in older cases where a simple myotomy was done to correct the deformity. Whether or not the muscle was contracted *in utero* has not been determined. This seems doubtful because of the normal appearance of the uninjured portion.

Two of these cases, however, were apparently normal deliveries. They are sisters, and it is interesting to note that another child in this family, one of two brothers, also had a torticollis, which was associated with a mass in the side of his neck. There is said to have been no difficulty in his delivery. Correction was made at 9 months of age by simple myotomy and the result has been excellent. If these muscles were contracted *in utero*

they alone were so affected, and furthermore, so far as the microscope can show, a large part of them was made up of normal muscle tissue. In each of these cases there seems to be no doubt of a rupture or partial rupture of the muscle. The type of scar tissue present attested its recent origin.

Von Landgraf has reported early myotomy in torticollis with unusually good results. With only 4 cases, it would seem from this study also that early operation is indicated. The operation causes practically no shock to the infant. The period of treatment is shortened. The secondary occurrence of facial asymmetry and scoliosis is thus avoided. The reaction of young tissue to operation is exceedingly good, and there does not appear to be any possibility of jeopardizing the result. Furthermore, a closer and more extensive study of the muscles in this early period may solve the problem of etiology and make possible the complete prevention of the lesion.

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RECONSTRUCTION OF THE HIP IN CASES OF IRREDUCIBLE DISLOCATIONS[1]

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A NUMBER of methods are employed for the correction, by open procedure, of the irreducible dislocated hip, but they will not be considered in this paper as they are fully described in the textbooks upon operative orthopedics. These methods have proved their great value to their originators, but none of them has more fully and more thoroughly undertaken to achieve what nature has failed to accomplish than has the procedure to be described. To produce security of the unstable hip—to render it a walking and supporting part for the lower extremity—is a tremendous task for any orthopedic surgeon; and finally, to establish such a hip as a durable, painless, and serviceable joint, is the end-result to which we aspire.

In developing the method to be described, I am indebted to Dr. A. Bruce Gill, of Philadelphia. The systematic, thorough technique embodied in this procedure is assurance of the soundness of the end-result. Possibly it may be said that in this technique there is nothing new, but it must be agreed that, even if there be a meshing or dovetailing of methods, the plan is what might well be classed as a systematic undertaking to be applied in the cases of hip dislocation that are to be corrected by the open method when reconstruction is the only choice.

While bloodless reduction might well be attempted in all cases of congenital hip dislocation, it should not be considered after a certain period in the life of the patient. Up to a certain age, ordinarily up to 10 years but not beyond that, the method merits full consideration. There is an occasional exception to this age limit, but in the great majority of the subjects beyond the tenth year, more especially those previously unattended, the method should not be considered with any great hope of success.

Attempt after attempt by means of this procedure may bring in a final effort the desired result—a reduced, painless, and functioning hip. It is important, however, that we know when to discontinue our efforts. Only the milder manipulations should be used, because even mild manipulations in bloodless reduction usually produce trauma and this is all the more true if extra force is used. Great caution must be exercised to avoid damage to the femoral head such as mushing, fragmentation, or atrophy. If numerous attempts at bloodless reduction have proved unsatisfactory, no further consideration should be given this method. Bloodless reduction when unsuccessful may be thwarted by a pathological block, and any hip presenting such a problem should be treated as a pathological dislocation.

INDICATIONS FOR RADICAL PROCEDURE

Reduction by the closed method should practically never be considered in diseased hips. Although occasionally the relaxed and paralyzed hip, the result of anterior poliomyelitis, may be reduced and maintained in position, after many trials such hip joints are not truly pathological problems. Relaxation of the structures about the joint allows it to slip apart. No serious difficulties arising from trauma and proliferative changes need be solved in this group while attempts at reduction are being made. In these cases closed reduction is often very simple and maintenance in position by proper fixation brings about the occasional functional hip. As mentioned, a functional hip is the occasional result of bloodless reduction, but very often the result is a disappointment and a failure. Such failure brings recognition of the need for some open, radical plan that will be the only solution for function and comfort in this group of hip dislocations.

The truly pathologically dislocated hip, the one which will not remain reduced or which cannot be reduced, is a very big problem. The hip presenting a joint in which there are pathological changes, destructive, proliferative, or both, should never be considered for correction by the bloodless method. It is useless. No skill of the best, nor patience of the utmost, can satisfactorily establish a hip joint in a dislocated hip of this group. A hip with capsular or soft structural changes which fails to maintain a reduction in position should never be looked upon as reducible by other than the open procedure. Such hips should be considered for correction as soon as the age and development of the subject permit.

GENERAL CONSIDERATIONS

The satisfactory handling of this group of cases demands thorough knowledge of the anatomy and pathology of the site for correction. It is a big undertaking, from the first inspection of the lesion to the day of the patient's discharge from the

[1] Extracted from the thesis presented to the Faculty of the Graduate School of Medicine of the University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Medicine for graduate work in orthopedics, 1928.

physiotherapeutic department. Every case is governed by its own requirements, although there is a similarity in technique. The undertaking ends satisfactorily in the mind of the orthopedic surgeon only when it becomes an improvement in the mind of the subject. There is some flexibility in the age issue, the range of cases here considered being from 4 to 30 years. It varies with the general physical condition and development of the subject, as well as the degree of pathology in the hip commanding attention. In this group of cases it becomes almost an axiom that the older the subject the more certainty there is of the arrest of any pathological process in the hip. Hence, favored with an established pathology, it becomes a surer workable proposition for the operator when he finds himself confronted with a dislocated hip for correction.

TYPES FOR OPERATION

In this paper we are confining ourselves to hips whether congenitally or pathologically dislocated, which are considered the hopeless types for securing functional articulation between the head of the femur and the acetabulum *per se*. That is to say, this reconstruction procedure is advocated where it is primarily realized that the acetabulum is gone, or so nearly gone that a new one or an almost entirely new one must be constructed to receive the head or reconstructed head of the femur.

TECHNIQUE OF RECONSTRUCTION OPERATION

General aspects. In no way is it fully determined what details shall govern the particular procedure in a given case until the hip commanding attention is opened. The operator must allow himself to be guided with certain mechanical and physiological expectations always before him. Every case after operation requires most particular consideration immediately after incisional closure. Fixation is a very important issue when the patient leaves the operating room, proper immobilization in a plaster-of-Paris cast being essential to ultimate success. Formidable as this whole undertaking may seem it is none the less simple when everything in the handling of this type of case becomes routine. The staff of nurses in the operating room arrange the particular armamentaria required. With the experienced orthopedist, the average time consumed for the procedure should not exceed 90 minutes from the time of incision to the time when the patient leaves the table in immobilization. As the operation is of major character the matter of shock must not be overlooked. Convalescence generally goes to a favorable termination without complications.

Gross indications. The reconstruction operation is advocated for correction of irreducible dislocated congenital hips—the type which has gone beyond the hope of reduction even by the open method, because of developmental changes due to growth and use of parts involved. The host of cases classed under the caption of pathological dislocations of the hip will also be discussed. In brief, consideration is given to that large group of cases in which the functionally impaired or the obliterated hip socket presents the problem of the construction of a new one.

Pathological indications. Pathological indications are to be found in ankylosis, complete or incomplete; in painful hips; in hips dislocated through paralysis; in hips causing a decidedly impaired and faulty gait; in hips in which better position and range of motion are desired; and in any of the combinations of these. When this plan is being considered active pathological processes in the hip must be ruled out. Most of the established processes have as etiological factors such problems as: unsatisfactorily repaired or ununited fractures of the neck of the femur where union is no longer obtainable, paralytic dislocation of the hip as from anterior poliomyelitis, pathological dislocations or fractures which are the result of a destructive process, such as tuberculosis, osteomyelitis, and hypertrophic arthritis. Further, if it is desired to minimize suffering from local or referred pain, and if ankylosis, complete or incomplete, in faulty position causes interference with weight bearing and gait, the hip reconstruction procedure is indicated.

The hip trough. A box or trough is used for the patient to rest upon during the operation. This box was originally designed by Dr. Edwin F. Patton, former resident surgeon of the Philadelphia Orthopedic Hospital, and further developed by the author. It does away with the constant annoyance occasioned by the adjustment of slipping sand pillows, and it retains the patient at any desired angle from the horizontal plane to about 70 degrees. A description with photographs of this trough, which can easily be built by a carpenter, follows:

The patient is placed upon the bare trough before he is given the anæsthetic, and the draping is done after the patient is taken from the anæsthetizing room to the operating room, where the preoperative sterile dressings are removed. A sterile pararubber sheet under a sterile muslin sheet is draped into the trough and under the patient. The trough rests upon the operating table in the direction of long axis to long axis. The trough and table are now ready for the draping. The hip

trough has the advantage that the field of operation is at a higher level than it would be ordinarily if the patient were placed directly upon the operating table. The patient is placed in the trough so that the back rests upon the broad side or base board, while the well hip is upon the narrow side or vertical board away from the operator. The hip to be corrected is directly upward and before the eyes of the surgeon. A number of favorable and easy working angles from the horizontal plane of the operating table are available—a most desirable feature since the operating field may thus be brought from time to time into the operator's direct line of vision and working plane and ready access to the joint is thereby established. Thus when the crucial incision for the approach to the hip joint is made, the operator sees readily as he cuts directly down upon the field.

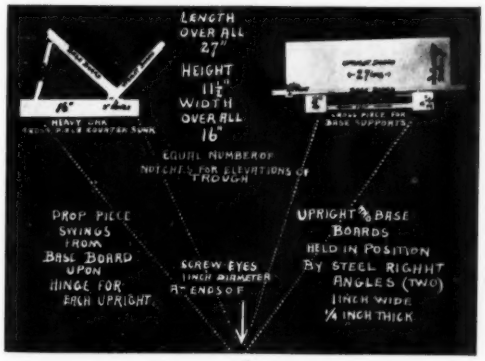
LENGTH OVER ALL 27"
HEIGHT 11"
WIDTH OVER ALL 16"
EQUAL NUMBER OF NOTCHES FOR ELEVATIONS OF TROUGH
PROP PIECE SWINGS FROM BASE BOARD UPON HINGE FOR EACH UPRIGHT
SCREW EYES 1 INCH DIAMETER AT ENDS OF
UPRIGHT & BASE BOARDS HELD IN POSITION BY STEEL RIGHHT ANGLES (TWO) 1 INCH WIDE ¼ INCH THICK
x

Fig. 1. Trough dimensions. *x*, Base supports, 3-inch rubber pads at ends, attached supports with hinges.

Steps of operation. Ideally, the Smith-Petersen approach is the incision of choice. This may be, in fact frequently is, modified; for example, the Sprengel encircling incision may be used. This incision fully follows the crest of the ilium forward, and then it passes downward toward the great trochanter of the femur. An assistant takes hold of the foot of the extremity being operated upon, and with varying movements for adduction, abduction, internal and external rotation, assists in defining the joint capsule. The capsule is opened without fear of destruction of the ligamentous coverings, and in order to obtain a full view of the head of the femur, the entire obstructing portion of the capsule is cut away. The assistant continues the movements of the leg through the various arcs, so that the operator gains further access between the head of the femur and what may have been the articulating surface of a remaining acetabulum. All ligamentous structures encountered during exposure of the joint may be freely separated in the manner which makes approach and enucleation of the femoral head easiest. It will be found that these structures are, in the majority of instances of irreducible hips, very much changed, atrophied, and distorted. In many cases they are simply remaining non-functional attachments to the ilium and head or neck of the femur. Any partially or completely ankylosed joint surfaces of the hip should be chiseled apart.

After the pathological hip joint and the head of the femur have been explored, the distortion and position of the latter, which are the unfortunate accomplishment of weight bearing and other mechanical forces, should be considered and the plan of possibilities for correction mapped out. If a fairly correct acetabulum accommodates a slipping head, then the simple procedure of establishing a check-ledge to stop slipping in the commonest direction for dislocation, is considered. If, however, the femoral head cannot be reduced, then a new acetabulum at the site of lodgement of the head against the ilium is demanded. In any event the procedure for establishing a check-ledge is necessary, and its size depends upon the demand. Thus for a simple slipping head which dislocates in an upward, backward, or combination of both directions, in fact in any direction, a check-ledge to stop this slipout from the acetabulum is necessary. This should be established in the location and at approximately the exact site out of which the head passes upon the ilium. If, however, the head cannot at any time or in any ordinary manner be brought down to where the original acetabulum should still be evident by means of X-ray, it then becomes necessary to build a suitable check-ledge or new acetabulum upon the iliac wing, around the newly established socket or point of impact of the head of the femur against the ilium. The new socket should be constructed well anterior on the ilium. Drawings will serve to clarify the technique.

The autogenous bone wedge. In all cases of hip reconstruction done in accordance with Dr. Gill's method, autogenous bone is used. From such, chips are made to be used for wedges between the shelf of bone that shall function as a check-ledge and the wing of the ilium from which the flap is lifted. As the check-ledge or crown, into or against which the head of the femur rests, is turned down from the ilium, its base or iliac attachment becomes that portion directly over or nearest the buttress point of the head of the femur. This is the only attachment which the check-ledge has to the parent-bone. The space between the check-

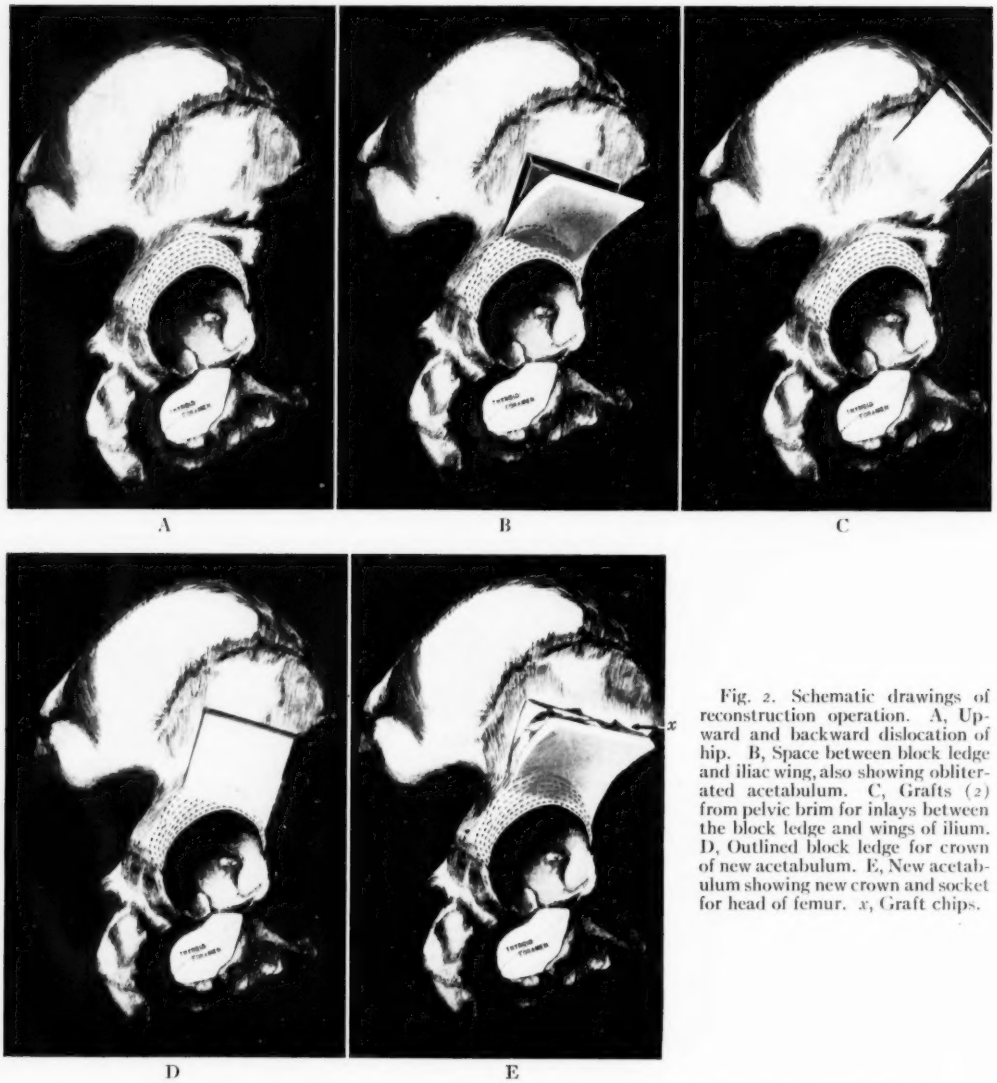

Fig. 2. Schematic drawings of reconstruction operation. A, Upward and backward dislocation of hip. B, Space between block ledge and iliac wing, also showing obliterated acetabulum. C, Grafts (2) from pelvic brim for inlays between the block ledge and wings of ilium. D, Outlined block ledge for crown of new acetabulum. E, New acetabulum showing new crown and socket for head of femur. *x*, Graft chips.

ledge and the point from which it is swung away, must be solidly packed with autogenous bone chips. They are conveniently taken from any denuded outer portion of the crest of the ilium. These grafts are chiseled off in quite large sections and divided or broken into pieces suitable for firm wedges that will keep the ledge or crown from turning back again toward its former seat in the iliac wing. After the check-ledge is solidly wedged and the new or reconstructed acetabulum is firm, with the head of the femur snugly resting against it, plans for closure follow. To close the wound the assistant must hold the extremity in the position which is best suited for cupping the head of the femur against the new acetabulum, this being merely a newly formed buttress against which the head of the femur must jam for future weight-bearing. The big problem after the completion of

the constructed hip joint is the maintenance of the head of the femur against the wedged ledge of the ilium, which replaces the former socket, into which the femur would have normally rested. The need of fixation, for the making of this new joint, begins immediately when the operator has finished with his last suture. With the operation field closed, all coverings and drapes are removed. Frequently tenotomies for allowing any of the contracted musculature of the thigh which may be in flexion or adduction to relax, become the necessary procedure in the course of the work toward the termination of the operation. Checking, prevention of assuming the position of full extension and outward rotation of the affected extremity, is not an unusual difficulty; it is due to shortened muscles of the adductor group and the sartorius. The fixation problem is an important issue.

Fixation and recumbency. Since recumbency with fixation is the immediate matter after the operation upon any such case, this consideration is next in importance. Recumbency of the patient often requires the application of a fixation principle which is at variance with the ordinary problem of rest in bed. In fact, cases in some instances are placed in fixation where the hip operated upon requires the hanging of the extremity out of bed as at a right angle to the body, in full abduction and internal rotation. Others are placed in fixation with the hip in hyperextension, inversion, and with only slight flexion at the knee. Such positions are for the purpose of maintaining the head in the newly constructed acetabulum. Reduction can be obtained only by a combination of any of the normal movements of the head of the femur in a normal acetabulum. Maintenance of position must therefore be obtained with recumbency after hip reconstruction, and it must be secured regardless of position of extremity with its relation to the horizontal plane of the body.

Casts vary with the type of case, but it is important to realize the necessity of building the cast high upon the trunk. It is safe to place such fixation almost to the level of the nipples and down upon the extremity to meet the various needs for fixation. Thus little or no mobility occurs in the immediate field of operation, and this is all the more effectively accomplished when the cast passes well down upon the extremity involved in the correction. The body cast may extend down the leg as far as the knee, below the knee, or down to and including the toes. The length varies according to the demand for proper position for immobilization.

The cast is worn for 6 weeks, after which the leg is immediately prepared for the application of extension and weights. Buck's extension apparatus is applied upon the leg 24 to 48 hours after removal of the cast and is heavily although comfortably weighted. While the leg is in the cast, repair is the only matter to be desired, and for this there need be little concern.

REHABILITATION

Promptly after the cast is removed, and while the extension apparatus and weights are still in use, the physiotherapist commences treatment to recondition the hip and entire extremity. Manipulations for short periods daily begin at once. The normal ranges of motion are attempted for longer periods each day as the patient's particular condition will permit. The weighting is continued, except during the massage and manipulative periods, for 4 weeks. For 2 weeks more the weights are retained only at night. The patient is encouraged to do all active movements at any time after the physiotherapist has begun manipulations. Weight-bearing is forbidden with or without support at this time. At the end of 6 more weeks the patient may go about on crutches wearing a 2 inch elevated shoe on the foot of the unoperated extremity. For the hip and leg operated upon a single-bar pelvic-band thigh-brace is applied down to the knee. The elevated shoe is discarded from the opposite foot about 4 weeks following its adoption. Full weight bearing with supporting brace is allowed from 6 to 8 weeks after patient begins going about on crutches. In other words, the patient walks around with the use of the brace about 18 weeks after the operation. The wearing of the brace is continued for a further variable period of from 6 to 8 months from the day of operation upon the hip. Massage and passive movements are wisely continued even after the brace is discarded. The latter recommendation is made upon the basis of the value of exercise for any weakened part.

SUMMARY

In summarizing this subject the following facts are brought forward with the view of stressing the desired possibilities when the procedures here presented are properly followed:

1. Bloodless reduction of the congenitally dislocated hip is definitely limited. When this is passed the method of open reduction is a definite solution, and it is being increasingly adopted.

2. Pathological hip dislocations should be considered for correction only by the reconstruction method.

3. Hip reconstruction is a definite possibility for producing a stable, painless, and weight bearing extremity with comfort to the patient.

4. The plan for reconstruction devised by Dr. Gill is thorough and carefully detailed, so that the end-results promise much satisfaction when properly undertaken.

5. The possibility of establishing a check-ledge or crown, which in reality means a new acetabulum, solves the problem of the irreducible, painful, and completely or partially ankylosed hip.

REPAIR OF INCISIONAL HERNIA[1]

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DURING a serious abdominal operation, a noted American surgeon made the remark that he hoped the patient would have a postoperative hernia. After the operation was completed, he was asked why he made the statement. He replied that if incisional hernia developed it would mean that the patient had recovered.

The repair of postoperative or incisional hernia is usually not considered a hazardous surgical procedure unless the hernia is large. There are many causes for the development of such hernias and many persons are more or less incapacitated because of them. Obese persons are prone to the development of postoperative hernia and the risk of repair of the defect is high.

The most common postoperative complications from this type of operation are ileus and peritonitis. The replacement into the abdominal cavity of the large mass consisting of omentum and intestines may increase the intra-abdominal tension to a point beyond endurance, resulting in ileus with the possibility of peritonitis.

It has been observed that patients suffering from postoperative hernia may be operated on with minimal risk if they are put at complete rest for several days prior to operation. The purpose of this is twofold: (1) since the abdominal muscles are used little during this period of rest they lose their tone and become more elastic, and (2) the weight can be easily reduced. These two factors permit more stretching of the tissues and thereby not so marked an increase in abdominal tension as occurs if the operation is performed without preparation of the patient.

In almost every case of incisional hernia, an entanglement of intestine and omentum is adherent to the walls of the hernia. Careful dissection and replacement require time and add to the possibility of ileus, peritonitis, and occasionally

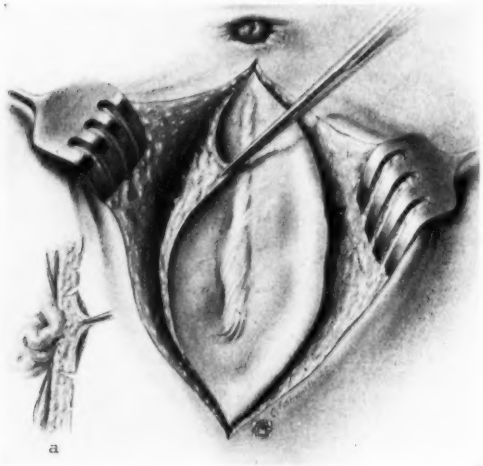

Fig. 1. Excision of the scar.

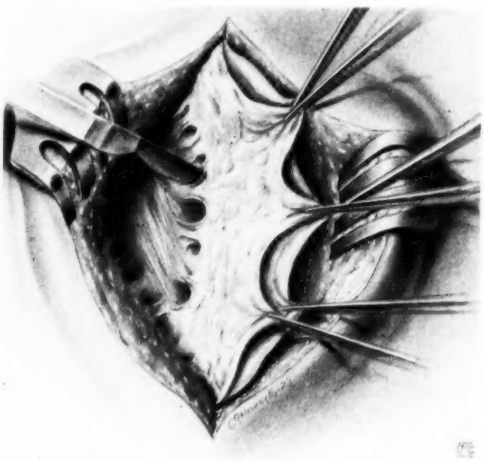

Fig. 2. Removal of scarred tissues.

[1]Submitted for publication October 26, 1928.

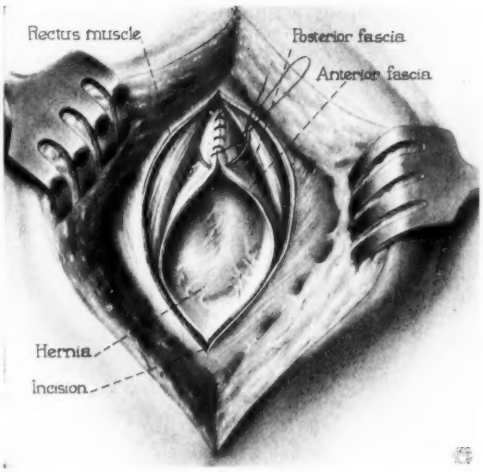

Fig. 3. Inversion of fascia by means of running suture.

Fig. 4. Overlapping and closure of anterior fascia.

hæmorrhage. The procedure suggested here has been used in several cases with uniformly good results.

A rather wide incision is made in the skin and is carried down to the fascia. The edge of the area of skin to be removed is then grasped with forceps (Fig. 1). Traction is made while the dissection is directed to the hernial mass. Great care is exercised not to injure the intestine and if possible the peritoneal cavity is not opened. If a small opening is made it is immediately closed by plain catgut sutures (Fig. 2).

After the hernia is bared (Fig. 3), an incision is made in the anterior fascia about 0.5 centimeter from its margin, extending throughout its circumference. The edges of this narrow margin of fascia are then approximated by means of a running suture (Fig. 3). By this procedure the protruding intestines and omentum are replaced in the abdominal cavity. The adhesions have not been disturbed and the peritoneal cavity has been only slightly opened, if at all. The anterior fascia is then overlapped (Fig. 4) by means of interrupted or running mattress sutures. Near the approximation of the two fascial layers a single running suture is used to prevent the possibility of small bits of fat working between the fascial layers. The edge of the fascia which has been overlapped is then sutured to its underlying portion.

SUMMARY

This method is suggested because it affords repair with a minimum of trauma to the intestines and omentum and decreases the chance of ileus and peritonitis, which are fairly common complications following repair of the incisional hernia.

Intestinal obstruction occurs occasionally as a result of postoperative or incisional hernia, but is usually the result of a loop of intestine finding its way out into the hernial sac.

It has been found that patients suffering from incisional hernia are more likely to have an uneventful convalescence if they are prepared for operation by being kept at complete rest for several days.

This method of repair of incisional or postoperative hernia has been used in many cases with excellent results and without fatalities.

SQUAMOUS CELL CARCINOMA ARISING IN A DERMOID CYST OF THE OVARY

Report of Three Cases[1]

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DERMOID cysts are the most common variety of ovarian tumor prior to puberty and they are often found at operation in women of all ages. They are usually classified as benign tumors, although malignancy may develop from any of the three germinal layers of which they are composed, giving rise to carcinoma, adenocarcinoma, and sarcoma.

In all the theories with regard to dermoids, there is the belief that they arise from embryonal deposits or misplacements, and general pathology teaches that any change in the position or normal structure of an organ or part of an organ creates a tendency to neoplastic formation and that any kind of embryonal misplacement or deposit is an excellent focus for the development and growth of a tumor.

Malignancy arising in a dermoid cyst of the ovary is not common. Martzolff found it in 0.5 per cent of cases, Koucky in 1 per cent, and Wiener in 5 per cent.

Because a dermoid cyst is found to be malignant does not indicate always that the malignancy originated within the dermoid. This can be determined only by a careful histological examination. The various possibilities are: (1) malignancy developing in the dermoid; (2) malignancy in a portion of an ovary or a malignant ovarian cyst associated with a dermoid in another part of the same ovary; and (3) malignant invasion of the dermoid from adjacent organs.

In the cases reported here squamous cell carcinoma arose from the dermoid itself. Many of the cases reported have been rejected because of insufficient evidence to classify them as cases of squamous cell carcinoma arising within a dermoid, and also because of previous failure to recognize a carcinoma associated with a dermoid or metastasizing to a dermoid instead of a squamous cell carcinoma developing in a dermoid.

Clark (1898) reviewed seven proved cases, including one of his own, of squamous cell carcinoma arising in a dermoid cyst of the ovary. Williamson and Barris (1911) reviewed thirty-two cases. They rejected fourteen cases, could not locate the references of two, and accepted sixteen as authentic. They added four cases of their own to the collection, making a total of twenty authentic cases reported.

In a thorough review of the literature we noted thirty-three cases (tabulation). To this list we add three cases from The Mayo Clinic.

REPORT OF THE MAYO CLINIC CASES

Case 1. A woman, aged 44 years, came to The Mayo Clinic complaining of soreness in the abdomen of 4 months' duration. She had had four children, two of them being stillbirths. The menstrual history was negative. Her mother had died of cancer of the rectum. A fibro-adenoma of the right breast had been removed 12 years previously. Six months before admission the patient decided she would reduce her weight and began to exercise. Two months later she noticed soreness in the abdomen. She consulted a physician because of this soreness and also because she had cancerphobia.

The patient weighed 185 pounds. Her height was 5 feet 6 inches. A hard, smooth, rounded mass in the lower part of the abdomen which resembled a pregnant uterus was palpated. On pelvic examination, the mass, which seemed smooth and about 20 centimeters in diameter, seemed to be a part of the uterus. Perineal and cervical lacerations were found. The hæmoglobin was 58 per cent. Erythrocytes numbered 4,100,000, and the leucocytes 600. The Wassermann reaction on the blood was negative. The specific gravity of the urine was 1.016; it was acid in reaction and albumin was graded 1. There were 12 pus cells to the field. Roentgenograms of the chest, intestines, and uterus were negative. A diagnosis was made of pelvic tumor, probably fibromyoma.

At operation a dermoid cyst the size of a 4 months' fetus was found in the region of the right ovary. It was adherent to the peritoneum and attached to the bladder anteriorly. There was a large nodular area on the surface of the dermoid (Fig. 1). It contained the usual dermoid contents. The mass was dissected free from the bladder and with it some of the muscular wall was removed but the mucous membrane was not incised. On account of adhesions a subtotal abdominal hysterectomy was performed with removal of both tubes and ovaries.

Convalescence was uneventful and the patient was dismissed about a month after the operation in good condition (August, 1924). She has not been heard from since this time.

Sections through the nodular area in the wall of the cyst showed masses of flat cuboidal and polyhedral cells of varying sizes with large nuclei. These cell masses were irregular

[1]Submitted for publication July 16, 1928.

Fig. 1. Dermoid cyst of the ovary with squamous cell carcinoma arising in the cyst, shown at the lower pole of the dermoid cyst.

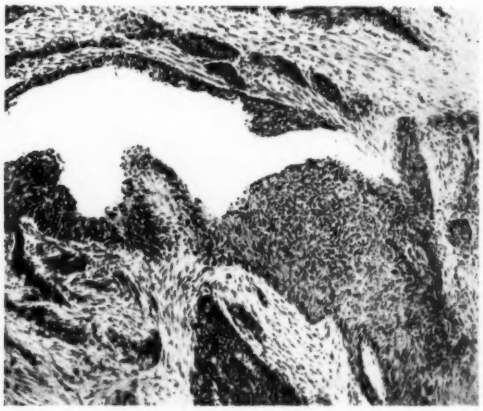

Fig. 2. Squamous cell carcinoma graded 3 arising in a dermoid cyst of the ovary. The irregular cell masses penetrated the connective tissue stroma with papilla-like projections. (× 60)

and surrounded by connective tissue and penetrated the connective tissue stroma with papilla-like projections (Fig. 2). In some sections the carcinomatous processes could be seen arising from the normal squamous epithelium which lined the cyst. There were scattered pearly bodies throughout, and one section showed dense masses of cells with numerous pearly bodies. The size of this nodular area was 9 by 5 by 4 centimeters. The final diagnosis was squamous cell epithelioma graded 3 in an ovarian dermoid cyst.

Case 2. The patient, aged 48 years, came for consultation because of abdominal pain. She had six children all of whom were living and well. She had been well until January, 1917, when she began to complain of intermittent soreness extending down from the umbilicus to the middle of the abdomen. The soreness had no relation to food nor was it relieved by food or soda. The patient had been compelled to use cathartics for the last 5 years, for constipation. She had been troubled with weakness, anorexia, and loss of strength for 2 months and had lost 35 pounds. At intervals for several years she had had nocturia two and three times every night.

The systolic blood pressure was 102; the diastolic 66. The pulse was 120, the temperature 101.4. The patient was rather thin and the skin was a lemon yellow. A large hard tumor, somewhat movable, extended from the pelvis to the umbilicus and seemed to be attached to the uterus. There was œdema in both legs, graded 3. The hæmoglobin was 29 per cent. Erythrocytes numbered 1,930,000 and leucocytes 21,800. Differential count was 300. Polymorphonuclear leucocytes were 73 per cent; small lymphocytes 13.7 per cent; large lymphocytes 9 per cent; eosinophiles 0.7 per cent; neutrophilic myelocytes 3.1 per cent; and normoblasts 2 per cent. There was slight anisocytosis. The Wassermann test was negative. Roentgenograms of the chest showed the heart to be enlarged and to the right. Probable malignant pelvic tumor was diagnosed.

A transfusion of 250 cubic centimeters of whole blood by the sodium citrate method was given September 10, 1917. September 17, 500 cubic centimeters of whole blood was given. September 22, 1100 cubic centimeters, and October 7, 750 cubic centimeters. The hæmoglobin was 54 per cent. The erythrocytes numbered 4,780,000.

October 8, 1917, operation was performed through a low median-line incision. The abdomen was filled with ascitic fluid. There were dense adhesions which made exploration of the upper part of the abdomen impossible. Nodular dermoid cysts of the right ovary were found. The largest of these was about 14 centimeters in diameter and appeared to be malignant. It had perforated and involved the small intestine. The right tube and ovary were removed and resection of about 30 centimeters of small intestine was necessary. Intensive roentgen-ray and radium treatments were given.

The patient returned December 17, complaining of a mass at the base of the abdominal incision. This was removed and found to be malignant. The patient died March 8, 1918, at her home. Necropsy was not performed.

Section through the malignant portion of the tumor showed large irregular polyhedral and cuboidal cells with large nuclei. Mitotic figures were seen. There were numerous irregular cell nests surrounded by connective tissue, and also papillary projections in the connective tissue in the stroma and numerous pearly bodies.

A diagnosis of squamous cell carcinoma in a dermoid cyst of the ovary was made (Fig. 3).

Case 3. A woman aged 67 years came for examination because of a "swelling in the abdomen." She had had six children and one miscarriage. The menopause had occurred at the age of 35. For the last 4 months she had noticed the progressive enlargement of the abdomen, associated with burning pain in the lower right quadrant. For the last 8 or 10 years she had had stomach trouble, characterized by distress after eating, a feeling of heaviness in the abdomen, and much belching.

The patient was rather slender. The abdomen was large. The heart was slightly enlarged on the left border, 15 centimeters from the median-line in the fifth interspace. A blowing systolic murmur was transmitted to the axilla. A large, hard tumor completely filled the abdomen and reached almost midway between the umbilicus and sternum. The cervix was lacerated and eroded; a cervical polyp protruded. The uterus was normal in size. The examination was rather unsatisfactory because the tumor filled the pelvis and abdomen. The specific gravity of the urine was 1.015; it was acid

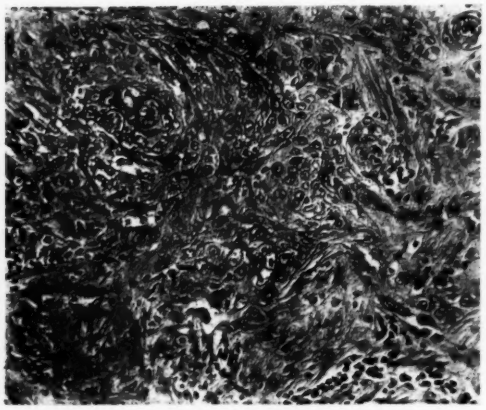

Fig. 3. Squamous cell carcinoma in a dermoid cyst of the ovary. (× 100)

Fig. 4. Squamous cell papillary epithelioma graded 2 in dermoid cyst of the ovary.

in reaction. Two pus cells were seen to a field. The hæmoglobin was 74 per cent, erythrocytes numbered 4,470,000, and leucocytes 6,500. Ovarian cyst was diagnosed.

At operation February 7, 1922, a large dermoid cyst of the right ovary filled the entire pelvis and the greater portion of the abdomen. The right tube and ovary were removed. The uterus and the left tube and ovary appeared to be normal and were not disturbed. The patient's general condition did not warrant further exploration. Since the cyst was adherent to the omentum in several places, resection of the omentum was necessary. The cyst was not ruptured in removal. Recovery was uneventful. June 7, 1927, the patient stated that she was in good health with no evidence of a recurrence.

The cyst contained hair and sebaceous material. There was a papillary area in the wall which measured 4 centimeters in diameter. Stratified epithelial cells and small cuboidal cells with rather large nuclei were noted microscopically. There were marked papillary projections and alveolar formation of these cells, and occasional pearly bodies. The final diagnosis was squamous cell papillary epithelioma graded 2 in a dermoid cyst of the ovary (Fig. 4).

COMMENT

All of the cases reported in the literature could not be accepted as squamous cell carcinoma arising in a dermoid cyst of the ovary. Some of the cases were rejected because of the too meager microscopic description of the specimen, some because of failure on the part of the author to state definitely the origin of the carcinoma. Others were rejected because they were frankly not cases of carcinoma. The cases rejected were those reported by Heschl, Pommier, Flaischlen, Babinski, Wahl, Carter, Cohn, Pottien, Seeger, Pomorski, Shoemaker, Souligoux, Morison, Wilms, Geyer, Le blanc, Wood, Mermet, Krecke, Lauro, Chavannaz, Gebhard (first and third cases), Newmann, Wittauer, Backhaus, Kehrer, Pompe van Meerdervoort, Fliedener, Clement, Peterson, Benjamin, Hicks and Targett, Norris, Dudgeon, Brettauer, Grant, Menestrina, Shaw, Franck, Nadal and Lacouture, Boxer, Hellier and Stewart, Stewart and Eglington, Kloss, Lapouge, Frank, Bab, Spalding, Potherat and Potherat, Frankl, and Eisenstaedter (first and third cases), Ewald, Faguet, Falk, Falkner, Khautz, Keitler, Kraemer, and Oliver.

The clinical differentiation of benign dermoid cyst of the ovary and dermoid cyst of the ovary with malignant degeneration is almost impossible. The earlier stages of malignant degeneration arising in a dermoid cyst cannot be diagnosed. However, if the carcinoma has advanced so that it has penetrated the wall of the cyst or has given rise to palpable metastatic nodules in the adjacent organs, the tentative diagnosis of malignancy in a dermoid cyst might be made if it is associated with a history of an abdominal tumor of long duration or with the history of recent rapid growth in the tumor associated with pain and a general loss of weight and strength.

In this series of cases the longest duration of the presence of tumor was 19 years and the shortest 6 weeks. Malignant changes in a dermoid cyst of the ovary usually appear as a few areas of vegetation on the internal lining of the cyst or as a simple thickening of the cyst wall.

The diagnosis can be made, usually, only by careful microscopic examination of the cyst after removal, and often malignant changes may escape notice. Malignant changes have been shown to occur in from 0.5 to 5 per cent of cases of dermoid cyst of the ovary, and it is probable that if careful

CASES FROM THE LITERATURE

Author, year	Age, years	Pregnancies	Duration		Diagnosis	Treatment	Comment
			Tumor	Pain			
Bierman 1885	21		4 mo.	4 mo.	Carcinoma of right ovary, ascites, hydrothorax		Death 3 days after examination. Dermoid cyst containing squamous cell carcinoma cell nests and epithelial pearls arising from right ovary and extending to left ovary, rectum, bladder, and uterus.
Himmelfarb 1886	55	9	1 yr.	4 mo.			Death in 3 weeks. Dermoid cyst of right ovary, attached to bladder which contained carcinomatous nests of cornified epithelium with carcinomatous changes of epithelium.
Krukenberg 1887	43	11	? mo.	? mo.	Ovarian tumor with carcinoma	Removal of tumor	Two dermoid cysts. Larger had areas of squamous cell carcinoma with epithelial pearls; metastasis.
Tauffer 1895	48						Death in 3 weeks. Dermoid cyst of ovary with metastasis, epithelial processes with cell nests and epithelial pearls in cyst wall; carcinoma.
Masson, Dor, and Berard 1896	53	1	6 mo.		Cystic ovarian tumor	Laparotomy	Large adherent multilocular cyst of left ovary with squamous cell carcinoma.
Thumin 1897	65	5	16 yr.	16 yr.		Removal of cyst with part of abdominal wall	Death in 6 months from recurrence. Dermoid cyst of ovary with squamous cell carcinoma with epithelial pearls arising from epithelial lining of cyst.
Yamagiva 1897	41						Death 11 months later. Dermoid cyst of left ovary with nodules of squamous cell carcinoma with epithelial pearls. Growths in mesentery.
Clark 1898	29						Dermoid cyst of left ovary with carcinoma arising from epithelial lining of cyst, epithelial pearls, metastasis.
Lockhart and Anderson 1899	50		6 mo.		Carcinomatous ovarian cyst	Laparotomy; cyst punctured	Death 5 weeks later. Tumor adherent to abdominal wall, omentum, liver, and intestines, multilocular dermoid cyst with squamous cell carcinoma, pearl nests.
Fairbairn 1899	66	4	6 wk.	occ.		Removal of tumor	Death 7 days later. Tumor of right ovary adherent to omentum, bladder, and abdominal wall, dermoid cyst with squamous cell carcinoma arising from wall.
Gebhard 1899							Dermoid cyst of ovary adherent to rectum, irregular size of cells and alveolar structure made diagnosis of squamous cell carcinoma of dermoid cyst.
Peters 1900	46	10	7 to 8 yr.			Excision of nodules from bladder and peritoneum, removal of cysts	Thirteen weeks later extension to rectum. Dermoid cyst of ovary adherent to rectum and pelvic walls, variable epithelial cells arranged in carcinomatous cell nests, carcinoma pearls, carcinoma one place in lining epithelium.
Klokow 1901	54	11	1 yr.	1 yr.		Removal of left ovary	Smooth dermoid cyst of left ovary with squamous or flat epithelial cells with alveolar formation, epithelial pearls and carcinoma in nodules.
Poelzl 1904	42		2 mo.	2 mo.		Removal of cyst	Well 4 months; died 2 months later, recurrence. Ruptured dermoid cyst of right ovary with squamous cell carcinoma arising from lining of cyst, pearl formations, metastasis to liver, omentum, and peritoneum.
Ludwig 1905	34			Few days	Malignant ovarian tumor	Removal	Good health for 2 years after operation. Myoma of uterus and dermoid cyst of left ovary with a solid portion which was composed of epithelial cells, carcinoma nests, epithelial pearls, squamous cell carcinoma.
Bab 1906	51			2 mo.	Malignant ovarian tumor	Removal of tumor	Dermoid cyst of left ovary with malignancy involving appendix, cæcum, and peritoneum. Epithelial pearls in carcinoma.
Garisoutouff 1907	45		2 mo.			Removal of tumor	Two months later recurrence. Died in 6 months. Dermoid cyst containing carcinoma with flat cells from squamous epithelial lining of cyst, intraligamentary tumor of left ovary.
Shaw 1910	47		3 yr.	3 wk.		Removal of tumor	Cyst of left ovary with squamous cell carcinoma arising from wall of cyst, small cell nests and cornification of epithelium.
Targett 1910	45					Removal of cyst	Death 13 months later, recurrence. Dermoid cyst of left ovary containing new-growth of squamous cell epithelium with cell nests.
Williamson and Barris 1911	40			2 wk.		Removal of tumor	Dermoid cyst with area of squamous epithelial cells, connective tissue stroma destroyed by cancer cells, cell nests.

CASES FROM THE LITERATURE—*Continued*

Author, year	Age, years	Pregnancies	Duration		Diagnosis	Treatment	Comment
			Tumor	Pain			
Williamson and Barris 1911	60			3 mo.		Removal of tumor, both ovaries, uterus, and right ureter	Dermoid cyst of left ovary involving right ovary in carcinomatous part, squamous cell epithelial lining and cell nests and masses of squamous epithelial cells.
Williamson and Barris 1911							Museum specimen. Dermoid cyst with mass in wall made up of squamous epithelial cells and cell nests.
Williamson and Barris 1911	47					Removal of cyst	Death 11 months later, recurrence. Dermoid cyst of right ovary adherent to bladder. Wall of cyst infiltrated by masses of squamous epithelial cells.
Reppun 1911	20		Several mo.	Several mo.	Tumor of left ovary	Removal of tumor	Death 3 days later. Dermoid cyst of left ovary with malignancy extending to sigmoid flexure and rectum. Squamous cell carcinoma with squamous epithelial cells and pearl formation.
Andrews 1914	49				Probably malignant ovarian tumor	Removal of portion of cyst	Multilocular dermoid cyst of left ovary with places in which squamous epithelial cells were arranged in network giving appearance of squamous cell carcinoma.
Lapouge 1914	47			2 mo.	Ovarian cyst in torsion	Removal of cyst	Well 7 years, recurrence in abdomen, died in 4 months. Dermoid cyst of left ovary with squamous cell carcinoma with epithelial pearls.
Wiener 1915	55	9				Removal of cystic left ovary	Dermoid cyst with squamous cell carcinoma.
Wiener 1915	50	2	19 yr.			Removal of cyst	Dermoid cyst with part of wall thickened with squamous cell carcinoma.
Pfeiffer 1916							Specimen only obtainable. Dermoid cyst of ovary with squamous cell carcinoma arising from lining and extending to sigmoid.
Eisenstaedter 1921	38		3 mo.	3 mo.	Malignancy of left ovary	Removal of cyst	Death 3 months later. Dermoid cyst of left ovary with nests of squamous cell carcinoma with cornification. Tumor adherent to intestines and bladder. Metastasis to bladder, mesentery, jejunum, and ileum.
Martzolff 1922	37	3	4 mo.				Death 3 months later. Ruptured cyst of left ovary involving tube and extending to rectum and uterus, unilocular cyst, dermoid lined with stratified epithelium, epithelial cells, epithelial pearls, and mitotic cells.
Wiener 1925	35		2 yr.			Removal of cysts	Recurrence 2 months later. Nodules in omentum and intestine. Ovarian dermoid cyst with squamous cell carcinoma.
Forster 1927	51		6 mo.	5 wk.		Removal of tumor	Cyst of left ovary adherent to omentum and ileum. Solid carcinoma with pearl formations in cyst and intestinal wall.

pathological examination was made as a routine the percentage of cases in which malignant degeneration is known to occur might be even larger. This should result in more careful pathological study of such tumors.

The age at which this complication arises appears to follow the same general rule as malignancy in other regions. The youngest patient noted in literature was 20 and the oldest 66. The average age at which the complication arose was 49 years; 40 per cent of the cases occurred between the ages of 40 and 50, and 25 per cent of the cases between the ages of 50 and 60.

The prognosis in these cases is grave; rarely do patients recover completely. In the series of cases reported in the literature the result was recorded in eighteen. In each case death occurred from within a few days after operation to within 2 years from recurrence with the exception of the case reported by Lapouge, in which the patient lived 7 years and then died from recurrence in the abdomen. Ludwig reported the case of a patient who was well at the end of 2 years, but further report was not given.

In our three cases one patient recovered uneventfully and has not been heard from since the operation. One died 5 months after operation from recurrence, and the third patient was well at the end of 5 years.

SUMMARY

Squamous cell carcinoma arising in a dermoid cyst of the ovary is not common, occurring in from 0.5 to 5 per cent of the cases. Thirty-three cases of squamous cell carcinoma arising from dermoid cyst of the ovary were reviewed from the

literature and three new cases added. The clinical differentiation of degeneration of the dermoid cyst of the ovary is practically impossible until the later stages. Microscopic examination is the only certain method of diagnosis. Every dermoid cyst of the ovary should be carefully examined microscopically for malignant change. The prognosis is grave unless the cyst is removed early. Exploration should be performed in every case of tumor of the ovary unless there is absolute certainty as to its nature.

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PUERPERAL INVERSION OF THE UTERUS

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PUERPERAL inversion of the uterus is one of those rare conditions which many surgeons have never met. The lesion is a complication of the third stage of labor and may be incomplete or complete. Uterine inversion is incomplete when the fundus of the uterus passes no further than to the cervix and complete when any part of the *corpus uteri* passes through the cervical ring. In extreme cases inversion of the vagina accompanies that of the uterus. Inversion of the uterus is said to be acute when it has existed less than a month and chronic when it has passed beyond this period.

Available statistics show that puerperal inversion of the uterus occurs on the average of once in 125,000 labors. This incidence is apt to be low, since the data is collected from large and well conducted obstetric clinics, and it seems logical to feel that it would be somewhat higher were statistics available for patients delivered in private practice in their homes by men less skillful in the practice of obstetrics. However this may be, with constantly improving obstetric practice, the lesion is getting even more infrequent.

From July 30, 1924, to March 3, 1928, in a period of less than 4 years, I have treated 3 cases of complete inversion of the uterus; one of them in the acute stage, the other 2 in the chronic stage.

CASE 1. Mrs. L. C., 29 years of age, was admitted in active labor to the Obstetrical Service of the Carney Hospital on March 2, 1928. Her family history showed nothing remarkable. She had had no previous severe illnesses or operations. Her menstrual history was normal. She had had two previous pregnancies, the first terminating as a spontaneous abortion at the third month; the second by the normal delivery of a living child in March, 1927. The present pregnancy evolved without complications. She started in labor on March 2, 1928. When she entered the hospital, examination revealed the vertex presenting in the left occipito-anterior position. The duration of labor was 10 hours and she was delivered of a living child by the house surgeon on duty on the morning of March 3, 1928. The perineum was intact. The fundus was held while the baby's cord was being tied. About 15 minutes after the delivery of the child the placenta presented in the vagina, and with slight traction on the cord, was brought to the introitus, where it was grasped with the hand in an attempt to remove it. After the greater part of it was delivered, it was found that the uterus was inverted and that the placenta was attached to it. The placenta was peeled from the inverted uterus. I saw the patient shortly after this and it was evident that a complete acute puerperal inversion of the uterus existed.

Under ether anæsthesia the uterus was manually reinverted starting with one horn, then the other, and finally the total reinversion was accomplished without any especial difficulty. As the patient was in considerable shock she was given 1700 cubic centimeters of salt solution by *hypodermoclysis*. She soon came out of the shock.

The puerperium was uneventful, the temperature rising to 100 degrees F. (37.7 degrees C) once on the third day when lactation was established. The pulse was 130 after delivery; it gradually came down to 90. The respirations were never above 22. The puerpera nursed her baby without difficulty. She was allowed out of bed on the tenth day and discharged on the twelfth, at which time the following note was made: "The breasts are normal and lactating, the abdominal muscles are firm, and the perineum is intact. Rectal examination shows the cervix closed, the uterus well involuted, in second degree retroversion, the adnexa normal, and the parametria non-sensitive. The baby's condition is excellent."

The patient has enjoyed perfect health since her discharge from the hospital and has been free from pelvic symptoms.

CASE 2. Mrs. M. D., aged 27 years, a secundipara, was admitted in labor to the Carney Hospital on June 26, 1924. She had had measles and pertussis in infancy; her tonsils and adenoids had been removed when she was 7 years old. Menstruation was established at the age of 14; her periods were regular, every 28 days, and lasted 4 days; 2 napkins were used daily and no clots were passed. Her last period had been on September 20, 1923, making her confinement expectation June 27, 1924. The patient had been married 3 years, and this was her second pregnancy. Her first child was delivered at 8 months for toxæmia and was stillborn. She had been well throughout the present pregnancy, and although albuminuria was present, no other signs of toxæmia were observed. Her pelvis was ample.

The patient started in labor at 3 p.m. on June 26, 1924; 2 hours later the membranes ruptured spontaneously. She was given ½ cubic centimeter of pituitary extract when her cervix was fully dilated. She was delivered, by low forceps, of a female child weighing 8 pounds and 6 ounces, by a member of the attending staff, at 7 a.m. on June 27, 1924. The placenta, which was inserted at the fundus of the uterus, was firmly adherent, and in attempting the Credé maneuver, the attendant inverted the uterus. The placenta was then peeled from the fundus of the inverted uterus; the organ was reinverted manually, without difficulty, and packed with sterile gauze. One cubic centimeter of a sterilized preparation of ergot was injected intramuscularly. Four ounces of ether had been administered during the delivery. One hour after labor the uterus was flabby and signs of a slow and persistent hæmorrhage were observed.

I saw the patient at 11 a.m., 4 hours after delivery, while making hospital rounds. She was then pulseless, was bleeding freely, showed signs of air hunger, and her condition looked desperate. At 11:30 a.m. she was given 1,000 cubic centimeters of salt solution subpectorally. At 2 p.m. she was given a blood transfusion of 600 cubic centimeters from her brother, by the citrate method, and her condition rapidly improved. She was discharged from the hospital

on July 13,1924, after an otherwise uneventful puerperium, by her obstetrician, who did not make a pelvic examination at the time of discharge. For this reason no note was made on the record as to the condition of the uterus.

One week later I was called in consultation by her physician, who felt that he had discovered a uterine prolapse. I saw the patient in her home and because of the lack of aseptic conditions preferred to do the internal examination in the hospital and advised her to come there at once. My advice was not taken, however, for she did not report until July 29, 1924. Upon admission, the patient stated that since leaving the hospital she had noticed loss of support and weakness. Upon standing, the parts protruded through the vulva, and she felt more uncomfortable from day to day. There was a persistent serosanguineous discharge. For the 2 days previous to her admission there had been some bleeding, amounting to stains of bright blood on her pad; she had passed a small clot the day before entering the hospital. She had been free from pain, her appetite had been excellent, and her bowels had been regular with the aid of laxatives. There had been some difficulty and burning at micturition, but at the time of admission, there was only slight difficulty in starting the stream. The urine had not been observed to be bloody, cloudy, or colored.

On separating the labia, it was evident that a complete inversion of the uterus existed. The uterine mucosa was grayish in appearance, bled readily on sponging, and the typical cup-shaped depression was apparent on vaginal and abdominal palpation. The cervical constriction ring was so tight around the uterus that it was impossible to reinvert the latter by taxis. The perineum appeared to have been recently repaired. The abdominal walls were considerably relaxed, otherwise the abdomen was normal. The heart and lungs were normal. The urine showed nothing remarkable.

On July 30, 1924, 34 days after the accident, the patient had an anterior colpohysterotomy (Spinelli's operation) performed, under ether anæsthesia. The uterus was exposed by the use of a weighted speculum, the œdematous endometrium presenting. The cervical ring was grasped on either side of the median line by Jacob's vulsella and brought down into view. The anterior vaginal fornix was incised, the bladder was separated and held upward by a retractor, the peritoneal cavity was opened, and the inverted funnel was exposed. No adhesions were found. The cervical ring was divided in the median line, and the incision was continued downward along the anterior wall of the uterine body to the fundus. The uterus was reinverted without any especial difficulty. The anterior uterine incision was closed by two layers of interrupted sutures of No. 2 chromic catgut, the first layer deep and the second superficial; the uterine wall was approximated without undue tension. The uterus was then replaced in the abdominal cavity, and free drainage was established by means of T-shaped rubber tubes, the first tube being placed between the uterus and the bladder, and the anterior vaginal incision being closed around it by means of interrupted sutures of No. 2 chromic catgut. A small transverse incision was made in the cul-de-sac of Douglas, and the second drainage tube was placed posterior to the uterus. The vagina was lightly packed with iodoform gauze, and the patient was returned to her bed in good condition.

The patient had considerable postoperative nausea and vomiting. The evening temperature was 102 degrees F., pulse, 118; respiration, 22. She was kept comfortable with small doses of morphia. July 31, there was a slight amount of distention which was relieved by enemata. The postoperative urine examination revealed negative findings; the evening temperature was 102 degrees F., pulse, 120; respiration, 20. August 2, the iodoform wicks were removed from the vagina; the convalescence thus far was satisfactory. August 4, the two drainage tubes were removed. August 9, patient was given a head rest; she was allowed out of bed on August 11. The discharge examination showed the uterus in mid pelvis, the drainage tracts healed, and no pelvic tenderness. August 16, the patient was discharged well.

Subsequent history. September 26, examination at the hospital showed the vaginal incisions and the cervix well healed, the uterus in slight retrocession, the adnexa normal, and the patient without symptoms. She had not menstruated in August, but had had a period, without pain, from September 1 to September 3.

December 31 the following history was obtained: she menstruated, without pain, in October, from the 20th to the 25th; she had no period in November; in December she had a scanty period, without pain, from the 15th to the 18th. The examination at this time showed nothing new except that the uterus was in second degree retroversion. The patient felt well and had gained 30 pounds in weight since her operation. On April 8, 1925, she was admitted to the Medical Service of the Carney Hospital; the examination of the lungs and the X-ray findings led to the diagnosis of chronic fibroid phthisis. Her periods had been regular up to the time of her admission. She was given medical advice for the treatment of her pulmonary condition and she returned to her home. July 25, 1925, her family physician reported that she was now living in the country; that her tuberculosis process was arrested, and that she was gaining in weight.

Case 3. Mrs. N. F., aged 33 years, was seen in consultation at a private hospital on April 25, 1927. Her family history showed nothing remarkable. She had had no previous severe illnesses. Menstruation was established at the age of 12, her periods were regular, every 28 days; they lasted 3 to 4 days, and no clots were passed. The patient had been married 4 years, and had been delivered of 2 children. The first labor had been terminated by mid forceps, and the second by a low forceps operation. Both children are living and well. The present illness dated from February 6, 1927, the day of her second delivery. The attending physician stated that the delivery had been a simple one terminated by low forceps, that the placenta was intact and the membranes were complete, no abnormalities having been noticed after the third stage of labor. Soon after the delivery, however, the patient began to bleed more than normal from the vagina. This bleeding persisted up to April 25, 1927, at which time I saw the patient. The bleeding seemed to increase in amount, so that for 2 weeks preceding my visit the patient had been frequently packed. Her appetite was good; her bowels were regular; there was no difficulty with urination; she did not complain of headaches, and there were no nervous symptoms.

I saw the patient in the late forenoon on the date mentioned. The general examination was negative except for a pronounced degree of secondary anæmia. Vaginal examination showed a moderate amount of relaxation of the outlet and a freshly healed perineum. The examining finger introduced into the vagina met a pear shaped body but could detect no external os. Higher up a definite constriction ring was found about the uterus. By means of a speculum it was found that the mucosa of the fundus of the uterus was presenting and this bled readily on sponging. A diagnosis of chronic inversion of the uterus was made, and the patient was prepared for operation, this being done at 5 p.m. on the same day. The uterus had probably been inverted for about 2¼ months, that is, since the time of her last delivery.

Anterior colpohysterotomy (Spinelli operation). The technique of the operation was exactly that quoted in Case 2, with the exception that no iodoform gauze was left in the vagina. The patient left the table in fairly good condition.

The patient ran a septic course for 4 weeks following operation, the temperature ranging from 104.6 degrees F. to normal; the pulse ranging from 144 to 76 and the respirations from 50 to 20. On April 27, 1927, the second day after operation, a citrate transfusion was performed, 500 cubic centimeters of blood being administered. On the fourth day after operation the posterior vaginal drain was removed and on the seventh day the anterior vaginal drain. The patient had several chills during the first month following operation, and although the temperature rose each night to the vicinity of 104 degrees F. her pulse very seldom went above 100. The transfusion incision in the arm became septic and for a number of days pus exuded freely from that region. This readily cleared up, however, under Dakin's dressings. Several pelvic examinations were made, as it was felt that an abscess might be developing in the pelvis; nothing abnormal was found pelvically at any time. The incisions in the uterus and the drainage tracts in the vagina healed by first intention and caused no disturbance. The patient always looked fairly well despite the fact that she had a high temperature. She was discharged on May 29, 1927, 34 days after operation. At that time the examination revealed the following: The perineum was well healed; the vaginal incisions and drainage tracts were well healed; the uterus was in second degree retroversion and movable; the adnexa were normal; there were no masses or areas of tenderness in the pelvis. The patient has continued to improve since her return home. In October, 1928, her family physician stated that she was in good health and had no pelvic disturbances.

SUMMARY

Puerperal inversion of the uterus is a rare condition, the predisposing causes of which are uterine inertia, pressure on the fundus from above, and traction on the cord from below. Shock is the leading symptom and when this occurs after the third stage of labor, uterine inversion should always be borne in mind. In acute cases the uterus should be reinverted, manually, when possible, as soon as the condition is discovered. In cases in which this is not possible, laparotomy and reposition by taxis seem to give the best results. Chronic inversion is well treated by the vaginal method; anterior colpohysterotomy (Spinelli operation) when the uterus can be saved, vaginal hysterectomy when the opposite obtains. The shock should be combated by blood transfusions before attempting the operative procedures. The obstetric future of a woman who has had a Spinelli operation should be that of one delivered by a previous classical cæsarean section.

CORRESPONDENCE

THE BILLROTH I RESECTION OF THE STOMACH

Dr. Victor Orator, the author of "The Billroth I Resection of the Stomach," which was published in the Department of Clinical Surgery of the September, 1928, issue of SURGERY, GYNECOLOGY AND OBSTETRICS has asked the Editor to call attention to the fact that Figure 3 as published illustrates the end-to-side modification of the Billroth technique (Haberer-Moynihan). Illustrations as published were drawings made from photographs which were submitted with the article and the author had no opportunity to examine the drawings before the publication of the article. Dr. Orator does not believe that Figure 5 accurately represents the facts. Unfortunately, these corrections have of necessity been delayed.

EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

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ALLEN B. KANAVEL, M.D. ..... Associate Editor

WILLIAM J. MAYO, M.D. ..... Chief of Editorial Staff

MAY, 1929

TUBO-OVARIAN DISEASE

WITH reference to tubo-ovarian disease, Doctor William J. Mayo remarked recently that the case had been argued ever since he had been in surgical work. Yet efforts at formulating the present status of the treatment have their value, however much the points of view may vary. We reach agreement in actual cases more readily than in the abstract. This is quite in contrast to diplomacy with its apparent ease of agreement in principle but disagreement in concrete problems.

The most important method we have in medicine of determining what is best in treatment is the objective statistical study of a large series of cases, especially with reference to a prolonged follow-up study. It is recognized that the statistical method is not entirely without criticism. This is because of the necessity of recording each individual case in final tabulations of more or less inflexible characteristics. It would be unfortunte if the method should tend to fix the deplorable custom of the use of the word "case" in the sense of seeming to overshadow the individuality of the patient and his particular ailment. That this is not always so, and that the shortcomings inherent in the method of statistics is recognized, is indicated by the desire frequently noted of amplifying the report by discussion of some of the cases in detail, citing those elements which did not lend themselves well to tabulation. In a further sense, all this is acknowledgment of the importance of the method of an older day of deriving general principles by drawing them out of a deep thoughtful consideration of striking experiences in individual instances. Artistic interpretation has ever been quite subjective in its method.

The following is in summation of still another attempt to state principles bearing on the treatment of tubo-ovarian disease.

1. Acute tubo-ovarian disease does not demand surgery unless a large pelvic abscess has formed.

2. Pelvic abscess is the only common dangerous complication of both acute and chronic disease of the uterine adnexa.

3. Pelvic abscess is best treated by vaginal puncture in the posterior fornix and the institution of drainage.

4. Acute tubal infection may subside so completely at times as to be looked upon as a self-limited disease.

5. In chronic pelvic inflammatory disease, occasionally even large pelvic masses probably due largely to adhesions may disappear.

6. Chronic tubo-ovarian lesions are peculiarly liable to acute exacerbations, and these recrudescences or reinfections in themselves should not be considered surgical while in the stage of fever and leucocytosis unless there is abscess formation.

7. However, operation in certain cases is justifiable when there is a suspicion of appendicitis. Then operation is so urgently indicated that it outweighs its doubtful value in cases of simple tubo-ovarian disease.

8. In those cases of chronic pelvic inflammatory disease leading to prolonged invalidism, operation becomes definitely indicated. It should consist of radical surgery, usually of bilateral character. As a rule, conservation of the ovaries or of portions of them and even of the uterus is of doubtful value. Yet leaving the cervix seems to be the proper course. Complete quiescence of the disease as indicated by prolonged absence of fever and leucocytosis is extremely desirable and the criterion of safe surgery.

Finally, as the disease of itself has a relatively low mortality, its treatment demands methods which should have no mortality. The attempts at justifying dangerous treatment on the ground of the difficult economic status of the patient is scarcely warranted. Surgery and economics should not be confused. Ward cases sometimes lead to this doubtful type of reasoning. Private work with its more intimate acquaintance with the patient and the family leads to sounder views on this subject. A single misfortune in private practice compels more regrets than can be wiped out by a high percentage of good results in general.

CHARLES W. HENNINGTON.

VALUE OF RECTAL TUBE IN OPERATIONS FOR ACUTE ABDOMINAL CONDITIONS

TO obtain an evacuation of the bowels the day after operation for diffuse septic peritonitis is often a matter of great importance and concern. After an experience extending over many years I feel confident in advising the use of a colon tube put into place during an abdominal operation, to accomplish this purpose. I feel that it is just as valuable and important as the stomach tube has been proven to be in preventing death from gastric dilatation. In a considerable number of cases of paralytic ileus it will prevent over-distension of the intestines. It should be used in all cases of peritonitis from whatever cause; in all cases of intestinal obstruction whether mechanical or paralytic; and in many operations upon the female pelvic organs to prevent adhesions to the small bowel or omentum.

A colon tube 32 inches long, with an eye at the side as well as at the end, passed with a corkscrew motion by an assistant or nurse can be guided by the surgeon with his hand in the abdomen past the "tricky" rectum and through the sigmoid to the splenic flexure or higher. It will then be seen how difficult or impossible it is without such help to pass a rectal tube up to or beyond the sigmoid. It almost invariably becomes arrested at a point 4 inches above the anus and then bends on itself and doubles up within the rectum. The tube should be passed well above the sigmoid and as far as the splenic flexure so as to remain in position. It should then be secured by a stitch to the skin about the anus and can be left from 4 to 6 days as occasion requires.

The chief benefits to be derived from its use are: first, it permits of an easy escape of gas and prevents distention of the large bowel; second, by holding the sigmoid flexure and the mesosigmoid across the brim of the pelvis it forms an effectual shelf which prevents the small intestine from falling into the pelvis; third, it enables one to administer saline and glucose high up into the colon where it will have a better chance of being absorbed and also will enable one to give enemata where they will be most effective. Should the bowel become irritated by the tube, and it occasionally does, a warm oil enema will relieve it.

HERBERT A. BRUCE.

MASTER SURGEONS OF AMERICA

ELISHA H. GREGORY

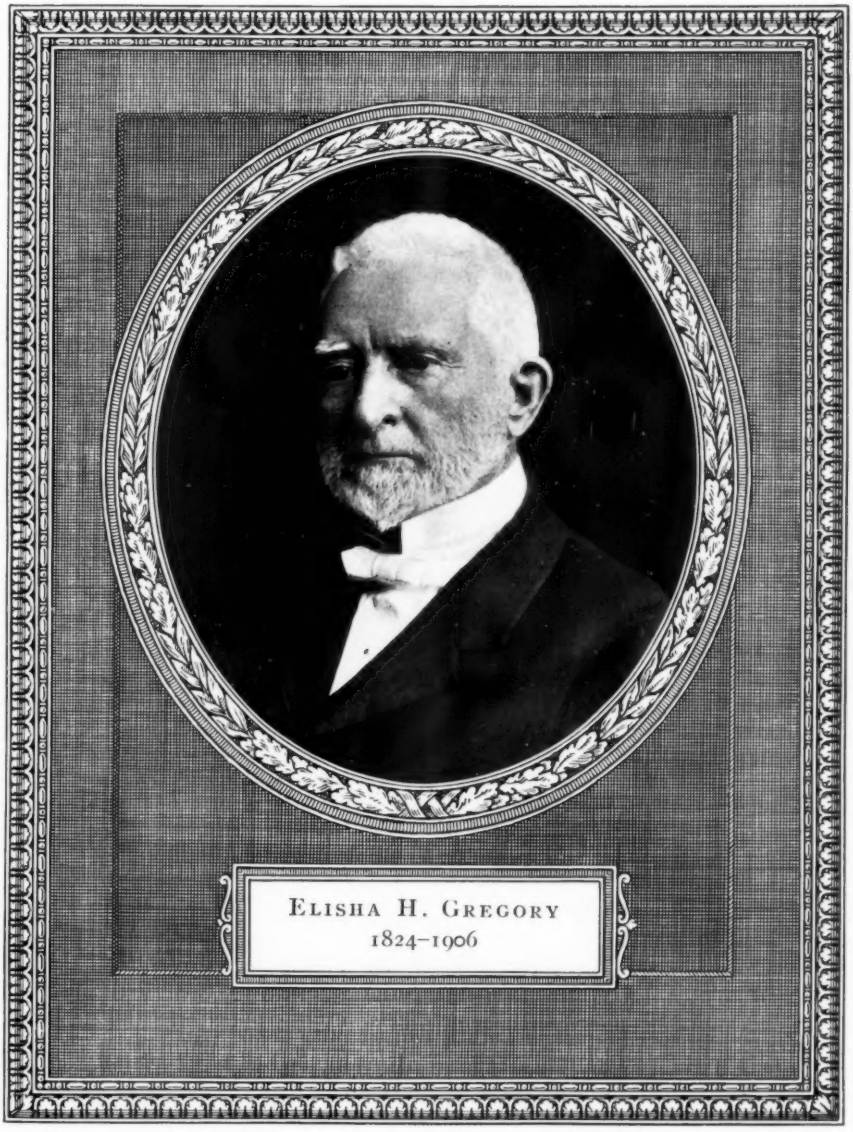
ON Sunday, February 11, 1906, there passed away at Ormond, Florida, at the age of eighty-two years, Dr. Elisha H. Gregory, for more than fifty years a resident and surgeon of St. Louis.

Dr. Gregory was born in Kentucky of parents descended from old Virginian stock, and the period of his education antedated that prescribed by Oliver Wendell Holmes for that of a gentleman. His seventeenth year found him living with his parents in a northern Missouri town, apprentice to a printer, and studying medicine from borrowed books at the same time. Two years later he attended a course of lectures in Louisville, and shortly after his return he was married to the life companion with whom many of us were acquainted.

The doctor's early efforts in the city were marked by the same energy which he had displayed in the country, and success came early. He made but one effort for a political appointment and afterward commented many times upon the ultimate failure of the more successful candidate. In the days when to be a surgeon meant more than the possession of a little technical skill such talent and energy as his brought him rapidly to the front.

The doctor was justly proud of his success. While it had its foundation in well regulated energy directed toward good, this simple man had many special qualities that added greatly to it. First and foremost, he seldom made a mistake in the estimation of a man's worth, and while he was sometimes tolerant beyond the limits of charity, I have seldom seen him misplace a trust. He had a trick of knowing when to act without asking questions, which, besides constantly saving him much time, was responsible for his surgeonship in the Mullanphy Hospital. Another habit to which he, himself, attributed much of his success was his ability to be on time for all his engagements; and he considered his meals not the least of these. Physically, he was not a strong man, but the habit of care which this engendered is probably responsible for the length of his useful life. It was the doctor's wont to refer to himself as unsophisticated, but he who acted on this idea was liable to make grave mistakes.

In questions of medical ethics he was almost always on the right, if not always on the successful side, and his policy has seldom been questioned. For years as a medical expert he was held in the greatest esteem, a terror to the



ELISHA H. GREGORY
1824–1906

evildoer, but more often a Godsend to the well intentioned medical brother who had been placed in a false or questionable position. He placed justice higher than friendship, by which he at times incurred ill-advised criticism.

I think his greatest talent was for teaching, or at any rate I am sure he was the greatest medical lecturer we have had. Here his concise knowledge, his pure logic, and his enthusiastic love of his subject combined in an effect that carried away both himself and his listeners, yet he has often said that he was extremely diffident about speaking in public and always avoided it when he could. This was not true about lecturing to medical students. He understood them and felt that they understood him. He liked to talk to them, and he put in his best work in the preparation of these lectures. He knew and loved each of his students, followed their careers with intense interest, and took the greatest pride in their success—and was given real pain by their occasional failures. There is no doubt that his teaching and working for the medical students was his greatest pleasure outside of his domestic life. He taught in the St. Louis Medical College and the Medical Department of the Washington University for fifty years; when he resigned it was with the protestations of his associates and students in the full possession of his powers and faculties.

Next to his students he loved his books. Not all books nor many books but those that tried to deal honestly with Nature in any of its phases either of mind or matter. He had an excellent library; most of the books were interlined and annotated by himself, and next to those whom he considered the masters of medicine, his favorite author was Shakespeare.

Of the number of offices that came to him I would mention just two. It was many years ago, while on the City Board of Health, that he succeeded in having the medical management of the City Hospital taken from political control—to which condition it has unfortunately since relapsed; and St. Louis once had the honor of seeing him president of the American Medical Association.

Dr. Gregory was essentially a surgeon, a safe operator, and an exponent of that greater surgery that recognizes Nature as the Master, a master not to be insulted by ill-advised interference. He operated unhesitatingly when he judged it necessary, but when there was a question he "gave the patient the benefit of the doubt" and waited a little longer. He hated mutilation of the human body to the point of passion and never did more than was necessary. Though he looked upon the advent of antiseptic surgery with much the same emotions as must have come to the patriarch of old when he gazed upon the promised land, still never an enthusiastic operator, the antiseptic technique, possibly because untrue, was irksome to him and before many years he began slowly but surely to withdraw from active practice. Every minute gained in this way was devoted to study, unhampered by the distractions of practice, until in his old age he was marching along in front of the procession of knowledge.

The great engrossing study of his life to which the latter years were entirely devoted was the subject of inflammation. With the older surgeons he had known it in all its forms and in all its manifestations, and yet as to its cause and its underlying processes, for the greater part of his life he could but guess. Can it, then, excite wonder if, after spending two-thirds of his life working in the dark, when Pasteur and Virchow and other such luminaries did add their light to his, he should have chosen to stop, to gaze on, and to revel in the illuminated landscape which his efforts had helped to light up, and with which he had become familiar while groping in the twilight of dawn? His address as president of the American Medical Association was at the time hardly accepted, yet today it contains but mere commonplace facts; while his final paper on "Inflammation" showed that he still maintained his advanced position.

There will be many tributes to his memory, but none will be given with more sincerity than this—that he was a simple man leading a simple life, seeking truth for its own sake, and doing good because it was right. V. P. Blair.

DISCORSO
DI PIETRO PAOLO
MAGNI PIACENTINO

Sopra il modo di fare i Cauterij ò Rottorij à corpi humani,

Nel quale si tratta de Siti, oue si hanno da fare, de Ferri che vsar vi si debbono, del Modo di tenergli aperti, delle Legature, & delle Palline, & dell'vtilità che da essi ne vengono,

Cose vtilissime non solo à Barbieri, ma à tutte le persone, che n'hanno bisogno.

CON LICENTIA DE SVPERIORI
IN ROMA, Appresso Bartolomeo Bonfadino.

ANNO D°
M·D·LXXX
VIII

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

ALFRED BROWN, M.D., F.A.C.S., Omaha, Nebraska.

PIETRO PAOLO MAGNI—ON THE USE OF THE CAUTERY

CAUTERIZATION represents one of the oldest of healing methods. Why this is so we can only surmise, but speculation is interesting and in this case seems to lead to a conclusion which is at any rate tenable. As far back as records go the four elements recognized were earth, air, water, and fire. Of these the last, fire, was the most mysterious as it appeared only occasionally, sprang from nowhere, and vanished into space, going apparently to the place whence it came—nowhere. With the acquisition of the method of starting fire and methods of keeping it under control it was found to be the great purifier and extremely useful in destroying material either harmful or no longer of use. We may imagine that as the methods of control became more efficacious and the fact was appreciated that fire transmitted its qualities to materials placed in contact with it, the idea filtered into the minds of our early ancestors that if this element would destroy harmful and noxious substances outside the body why would it not destroy the same things if present on the body such as dirty wounds, ulcers, and various growths? If this was the first step the amplification of its use was obvious and can be followed without great difficulty.

Whether the above approximates the true development or not the fact remains that the cautery became early firmly fixed in the surgical mind as a most efficacious, and we may judge for certain things the most efficacious, method of treatment. The aphorism of the fire is found in the ancient writings of different races. In the Hindu surgery it appears as "The fire cures diseases which cannot be cured by physic, the knife and drugs." Æschylus in his *Agamemnon* introduces the aphorism when he says, "What is lacking in the physician and drugs, I will then destroy utterly with the knife and fire." Hippocrates says much the same in his eighty-seventh aphorism, "Quæ medicamenta non sanant, ea ferrum sanat; quæ ferrum non sanat, ea ignis sanat; quæ vero ignis non sanat, ea insanabilia reputare oportet." "What medicines cure not, that iron (the knife?) cures; what iron cures not, that fire cures; what even fire cures not, that must be considered incurable."

Hippocrates used the cautery for almost everything even to the attempted cure of recurrent dislocation of the shoulder in which he burned the axilla with the idea of forming scar tissue which would prevent the head of the humerus from leaving the glenoid. Gradually more and more uses were discovered and the references to the cautery and its indications and forms of the instrument to be employed took up more and more space in surgical literature. Following Hippocrates, Aretæus of Cappadocia (A.D. 30–90) used the cautery in pleurisy and many other diseases. Soon after the introduction of the actual cautery another element than form of instrument entered, and we find long discussions as to the material of which the instrument is to be made. Aristotle, for example, advocated the use of bronze, and as we proceed along the line through the Byzantine surgeons and reach the Arabian School we come upon the great Albucasis who advocates iron, silver, gold, and brass cauteries and lays down definite indications for the use of each. He in turn was followed by William of Salicet and Guy de Chauliac, both great believers in the cautery.

By the sixteenth century the cautery had so far taken its place as a standard therapeutic item in surgical practice that it is mentioned by the wound surgeons only in passing—its efficacy being taken for granted by Brunschwig, von Gerssdorff, and the later wound surgeons of Europe. Then, with the dicta of Paré, the bombshell burst and the throne upon which the cautery had been so firmly seated for so long seemed to be tottering. The idol had been attacked and it was only natural that its votaries should come to its aid. Consequently at this time one finds special treatises devoted to the cautery, the most important being those of von Gavasseti (1584), Magni (1588), Costeo (1595), Fyens (1601), and Bartholinus (1624).

The "Discourse of Pietro Paolo Magni of Piacentino—Concerning the method of using the cautery in lesions of the human body etc." was published in Rome in 1588. Of its author Magni little is known except that he was a friend of Cardinal Farnese to whom he dedicates his book. His three friends A. Q. P., Joseph Castelio, and Celsus Cittadinus who wrote the dedicatory poems are apparently not men of prominence and tell us nothing of the author, who appears in the portrait woodcut as a fine looking man whose arms carry the motto, "With strength they do not fail." The volume most perforce be placed as one of the important compilations of the uses of the cautery by a practically unknown author.

REVIEWS OF NEW BOOKS

EVERY one recalls the time-old story of the dying father who adjured his two sons to cling, each to the other, and illustrated his preachment by demonstrating the great strength of fragile twigs when bound together. This story serves as an admirable text for a sermon on the inherent force of unified medical art and science. In these days of specialism, of an infinite number of cross currents, and of what the Germans call *tendenzen*, one must inevitably lose sight of the glorious whole unless he maintains his intellectual poise through the medium of medical history.

This latest edition of Garrison's *History of Medicine*[1] calls once again for recognition of the genius of the man who has been able to crowd between two covers the whole story of medicine, binding together with ramifying grasp both its art and its science, from primitive man down to the day before yesterday. Only he who has had occasion to use the book as a check against similar volumes can appreciate its accuracy and trustworthiness; but anyone with only a fair measure of love for the really artistic in literature will revel in these pages. Garrison is not one whit less "profound, sincere or eloquent" than is the great German master of medical history whom he admires so highly, and moreover he does preserve the saving grace of humor and that ineffable lightness of touch that we miss, not only in Neuberger, but equally so in Pagel, Baas, Haeser, and Sudhoff.

The reviewer would rather attempt to review a newly published dictionary, by selecting word after word for comment, than to review this volume in any sort of topical fashion. The ordinary book review should attempt to give the reader an idea of the content of the book under consideration and then judicially to evaluate the substance of the volume. This method of review should be so ordered that the reader might more or less subconsciously gain a totality of impression that would prompt him either to read the book or to eschew it.

In this instance, however, we are concerned chiefly not with the etiquette and the formal laws governing book reviewing but rather with the desire to do our part toward placing this enlarged edition of Garrison in the hands and under the eyes of every man who claims a relationship with medicine. It holds delightful surprises in store for them. From the almost Shavian preface, all the way through the appendices, that are baffling and confounding in their cleverness, attractiveness, thoroughness, and usefulness, the reader will lose himself in wonder and interest.

Such books as this, like truly great men, appear on the scene only at unpredictably long intervals.

M. G. S.

[1] An Introduction to the History of Medicine; with Medical Chronology, Suggestions for Study and Bibliographic Data. By Fielding H. Garrison, A.B., M.D. 4th ed. rev. and enl. Philadelphia and London: W. B. Saunders Company, 1929.

AT INFREQUENT intervals books cross the reviewer's desk that mark milestones in the progress of surgery, and it is a pleasure to record as such Dew's contribution on hydatid disease.[2] It is a volume of 400 pages, no one of which the reader would do without.

It is noteworthy for many reasons. Not since the classical works of Graham in 1891, and Thomas in 1894, has a complete work on this disease appeared in English. The author has had a wide experience (from a clinical standpoint) in the study of this disease in Australia and is in addition an investigator of note in this chosen field. He has the rare gift of combining in well balanced proportions the scientific contribution and the clinical aspect so that the book appeals not only to those who are interested in the latest additions to our knowledge, and they are many, but also to the clinical surgeon who is called upon to deal with this disease. He has dealt adequately with the modern methods of diagnosis and the various serological tests such as the complement fixation and intradermal reaction of Casoni, and has evaluated them from the standpoint of the clinical surgeon.

From the large amount of clinical material at his disposal he has produced a comprehensive discussion not only of hydatid disease as it appears in the various organs, but also of the complications that arise, such as hydatid anaphylaxis, and the consequences of improper surgical procedures. The contribution is one that will remain for many years as the authority upon this subject.

THE book on *Goiter Prevention and Thyroid Protection*[3] is a popular expression of the author's personal beliefs on his specialty. It is written to persuade the patient and seems unsuited for the scientific student of thyroid disease. To the reader the subject is made exceedingly simple. Goiter and Graves' disease become easily treated conditions which should cause no one any alarm. Thyroidectomy is, of course, brushed aside with a few prejudiced quotations. Exophthalmic goiter becomes a psychic disorder yielding to the author's regimen which is essentially one of psychotherapy. On the whole, although there is much good mental suggestion in the book, it is not to be recommended as a careful, unbiased study.

PAUL STARR, M.D.

THE monograph *Tumors Arising from the Blood-vessels*[4] covers another group of intracranial tu-

[2] Hydatid Disease; Its Pathology, Diagnosis and Treatment. By Harold R. Dew, M.B., B.S., F.R.C.S. (Eng.), F.A.C.S. Sydney: The Australasian Medical Publishing Company, Limited, 1928.

[3] Goiter Prevention and Thyroid Protection. By Israel Bram, M.D. Philadelphia: F. A. Davis Company, 1928.

[4] Tumors Arising from the Blood-vessels of the Brain; Angiomatous Malformations and Hemangioblastomas. By Harvey Cushing and Percival Bailey. Springfield, Illinois: Charles C. Thomas, 1928.

mors which have been studied in Dr. Cushing's clinic. This time the authors are concerned with the blood vessel tumors of the brain, 29 examples of which have occurred among 1522 histologically verified intracranial tumors. These 29 tumors have been further divided into the angiomatous malformations and the angioblastomata, or true neoplasms, arising from blood vessel elements. Among the latter are included the recognized examples of Lindau's disease.

The study of these tumors is presented in a manner which is suggestive of it having been done as a matter of record more than anything else. Therefore, it seems to lack the certain charm which one has been led to expect from the monographic reports which come from the Brigham Hospital clinic. The letter spacing style of emphasis is a bit annoying to the reader and does not lend itself to make an attractive printed page. LOYAL DAVIS.

ONE of the monographs of the Mayo Clinic series, *Thrombo-Angiitis Obliterans*[1] is written by men who have attempted to penetrate the maze of symptoms presented by vascular diseases of the extremities. The book gives one the impression that it is the result of their attempts to bring order out of chaos in their own minds concerning these conditions. Consequently, it is much more valuable than some others we have read because it is a bit more personal and human. Unfortunately, they chose the one vascular disease about which the most is known both clinically and pathologically as a result of Buerger's fine studies. Because of that, the most valuable portions are those dealing with the differentiation of the symptoms of thrombo-angiitis obliterans and Raynaud's disease, erythromelalgia, and other vascular diseases, and these are scattered.

The treatment of the disease is considered sanely and very honestly. Doctors Brown and Allen have had considerable experience in treating this condition with non-specific protein, and in their hands this has been highly satisfactory. In addition to its therapeutic value, the injection of non-specific protein has been used to determine which cases might be benefited by operations designed to create an efficient collateral circulation. They point out that one of these surgical procedures, lumbar ganglionectomy, is indicated in about 1 out of 7 cases. That fact, which is accompanied by accurate data, should be considered seriously by all surgeons who may be inclined to attack the sympathetic system rather empirically for most of the ailments from which man suffers. It is interesting to note that the authors feel that the results of periarterial sympathectomy are so slight or transient that the operation is not worth while. This conclusion is, of course, what has been maintained for some time by those who have considered the anatomical facts about the innervation of blood vessels.

[1] MAYO CLINIC MONOGRAPHS: THROMBO-ANGIITIS OBLITERANS; CLINICAL, PHYSIOLOGIC, AND PATHOLOGIC STUDIES. By George E. Brown and Edgar V. Allen; with the chapter on Pathology by Howard R. Mahorner. Philadelphia and London: W. B. Saunders Company, 1928.

While many conflicting physiological and clinical facts still remain unanswered, nevertheless, this is a valuable contribution to the treatment of vascular diseases which is welcome. It will help remove that attitude of mind recently expressed by a prominent advocate of perivascular sympathectomy in the treatment of these diseases. It was this: "If the patient shows definite improvement after the operation it is Raynaud's disease; if he doesn't it is something else." LOYAL DAVIS.

THE second edition of Labat's *Regional Anesthesia*[2] contains valuable additions to the original text. This book has contributed a great deal to the increasing popularity of local methods. While one may not agree completely with the author's selections of the most simple and yet effective procedures, there can be no doubt as to the great value of his descriptions based on a large experience both in teaching and practicing local anæsthesia.

The chapter on spinal anæsthesia has been enlarged. There is perhaps not enough stress laid on the use of ephedrine as a routine, preliminary injection. The control of the level of anæsthesia as advocated by Pitkin is not discussed, probably because the book must have been in press when Pitkin made his important contribution to the technique of spinal anæsthesia. The reviewer feels that the author's conception of the circulatory disturbances during spinal anæsthesia is not at all convincing. While there is a vasodilation in the anæsthetized field, no evidence is given that the blood accumulates in the entire dependent area, whether anæsthetic or not.

The printing and illustrations are of excellent quality. The book can be heartily recommended to the surgeon who is interested in improving his mortality and morbidity statistics by the routine use of successful methods. There are still too many men who believe only in an occasional use of regional anæsthesia for the poor surgical risk and who are painfully surprised when their occasional attempt proves to be a failure. Only a continuous practice can bring the expected results. GEZA DE TAKATS.

THERE will be some disagreement between some American workers and the English author of *Treatment of Venereal Disease in General Practice*,[3] E. T. Burke, who believes that the use of mercury in the treatment of syphilis is as obsolete as is the use of sarsaparilla in medicine. Mercury should be used in the treatment under two conditions: (1) that the patient is intolerant to arsenic and bismuth, or (2) that these two drugs are unobtainable.

In England, stabilarsan (salvarsan) is the drug of choice for intravenous use; for intramuscular use, sulpharsenol (sulpharsphenamine) is used. After

[2] REGIONAL ANESTHESIA; ITS TECHNIC AND CLINICAL APPLICATION. Gaston Labat, M.D. With a Foreword by William J. Mayo, M.D. 2d ed. rev. Philadelphia and London: W. B. Saunders Company, 1928.

[3] TREATMENT OF VENEREAL DISEASE IN GENERAL PRACTICE. By E. T. Burke, D.S.O., M.B., Ch.B. (Glas.). New York and London: Oxford University Press, 1927.

certain periods of arsenic treatment, intramuscular bismuth (bismostab) is used. The author describes uses of iodine which correspond to its uses by syphilographers in America.

Routine schemes of treatment for (1) early primary syphilis, (2) late primary syphilis, (3) early secondary syphilis, (4) late secondary syphilis, (5) endosyphilis, (6) tertiary and quarternary syphilis, and (7) neurosyphilis are briefly outlined.

Congenital syphilis may be defined as syphilis which is acquired *in utero* and which may or may not manifest itself at birth. Strictly speaking there is no such entity as hereditary syphilis. All congenital syphilis should be treated for at least a five-year period.

In his treatment of acute anterior gonorrhœa, the author strongly condemns any use of syringes by the patient because such procedures invoke posterior urethritis. He uses urethral irrigations of potash solution, one grain to the pint, from the start, and does all local treatment in the office. The drug recommended for his "sealed in" treatments is iodargol. Vaccines are given as a routine in every case. He adds that copaiba, sandalwood oil, and cubebs are nauseous drugs and should be entirely discarded in the treatment of gonorrhœa. No routine treatment is laid down for the treatment of posterior urethritis; no local treatment along with rectal suppositories of antispasmodics are recommended; he irrigates the bladder daily with potash solution.

In gonorrhœa in the female he permits the patient to irrigate her own urethra at home. Vaginal douches are given and the irrigant is held in the vagina by cotton packed around the douche nozzle to cause ballooning.

In the appendix of the book, the author states that intrathecal treatment (Swift-Ellis) of syphilis is physiologically unsound and therapeutically inefficient and should be abandoned. He believes this because (1) the pathological changes present in neurosyphilis are but rarely superficial and are not therefore reached by injections into the subarachnoid space; (2) the amount of arsenic present in auto-salvarsanized serum is of no treponemicidal value and (3) salvarsan substitute when given by the intravenous route reaches the central nervous system tissues and the cerebrospinal fluid in greater amount than can safely be injected intrathecally.

HARRY CULVER.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

MEDICAL REPORT FOR THE YEAR 1927. Glasgow Royal Maternity and Women's Hospital. Prepared by J. N. Cruickshank, M.D., F.R.F.P.S. (Glas.), M.R.C.P. (Lond.). Glasgow and Edinburgh: William Hodge & Company, Limited, 1928.

PROCTOLOGY; A TREATISE ON THE MALFORMATIONS, INJURIES, AND DISEASES OF THE RECTUM, ANUS, AND PELVIC COLON. Frank C. Yeomans, A.B., M.D., F.A.C.S. New York: D. Appleton and Company, 1929.

INTERNATIONAL CLINICS; A QUARTERLY OF ILLUSTRATED CLINICAL LECTURES AND ESPECIALLY PREPARED ORIGINAL ARTICLES ON TREATMENT, MEDICINE, SURGERY, ETC. Edited by Henry W. Cattell, A.M., M.D., with the collaboration of others. Vol. I. Thirty-ninth series, 1929. Philadelphia and London: J. B. Lippincott Company, 1929.

ULCÈRES DE L'ESTOMAC ET DU DUODÉNUM (ETUDE ANATOMO-CLINIQUE ET TRAITEMENT CHIRURGICAL). By Victor Pauchet, Gabriel Luquet, and A. Hirchberg. Paris: Gaston Doin & Cie, 1929.

DISEASES OF THE LIVER, GALL-BLADDER AND BILE-DUCTS. By Sir Humphry Rolleston, Bart., K.C.B., and John William McNee, D.S.O., F.R.C.P. 3d ed. London: Macmillan and Co., Ltd., 1929.

BIRTH, STILLBIRTH, AND INFANT MORTALITY STATISTICS FOR THE BIRTH REGISTRATION AREA OF THE UNITED STATES. Twelfth Annual Report, 1926. Part I. Washington: Department of Commerce, Bureau of the Census.

ANNALS OF ROENTGENOLOGY; A SERIES OF MONOGRAPHIC ATLASES. Edited by James T. Case, M.D. Vol. VIII. The Vertebræ Roentgenologically Considered. By Arial Wellington George, M.D., and Ralph Davis Leonard, M.D. New York: Paul B. Hoeber, Inc., 1929.

INJECTION TREATMENT OF INTERNAL HEMORRHOIDS. By Marion C. Pruitt, M.D., L.R.C.P.S. (Edin.), F.R.C.S. (Edin.), F.A.C.S. St. Louis: C. V. Mosby Company, 1929.

THE NORMAL AND PATHOLOGICAL PHYSIOLOGY OF BONE; ITS PROBLEMS. By R. Leriche and A. Policard. Translated by Sherwood Moore, M.D., and J. Albert Key, M.D. St. Louis: C. V. Mosby Company, 1928.

THE CLIMACTERIC (The Critical Age). By Gregorio Maranon. Translated by K. S. Stevens. Edited by Carey Culbertson, A.B., M.D., F.A.C.S. St. Louis: C. V. Mosby Company, 1929.

THE TECHNIC OF LOCAL ANESTHESIA. By Arthur E. Hertzler, A.M., M.D., Ph.D., LL.D., F.A.C.S. 4th ed. St. Louis: C. V. Mosby Company, 1928.

BLOOD AND URINE CHEMISTRY. By R. B. H. Gradwohl, M.D., and Ida E. Gradwohl, A.B. St. Louis: C. V. Mosby Company, 1928.

THE INJECTION TREATMENT OF HEMORRHOIDS. By Charles Conrad Miller, M.D. Chicago: Modern Surgery Publications, 1929.

DIE HYSTERO-SALPINGOGRAPHIE. By Dr. Nikolaus Temesváry. Stuttgart: Ferdinand Enke, 1928.

COLLECTED PAPERS BY MEMBERS OF THE GYNECOLOGICAL DEPARTMENT OF THE JOHNS HOPKINS HOSPITAL AND UNIVERSITY. Vols. A and B., 1922-1928.

BIRTH, STILLBIRTH, AND INFANT MORTALITY STATISTICS, 1925. Part II. Washington: Department of Commerce, Bureau of the Census, 1929.